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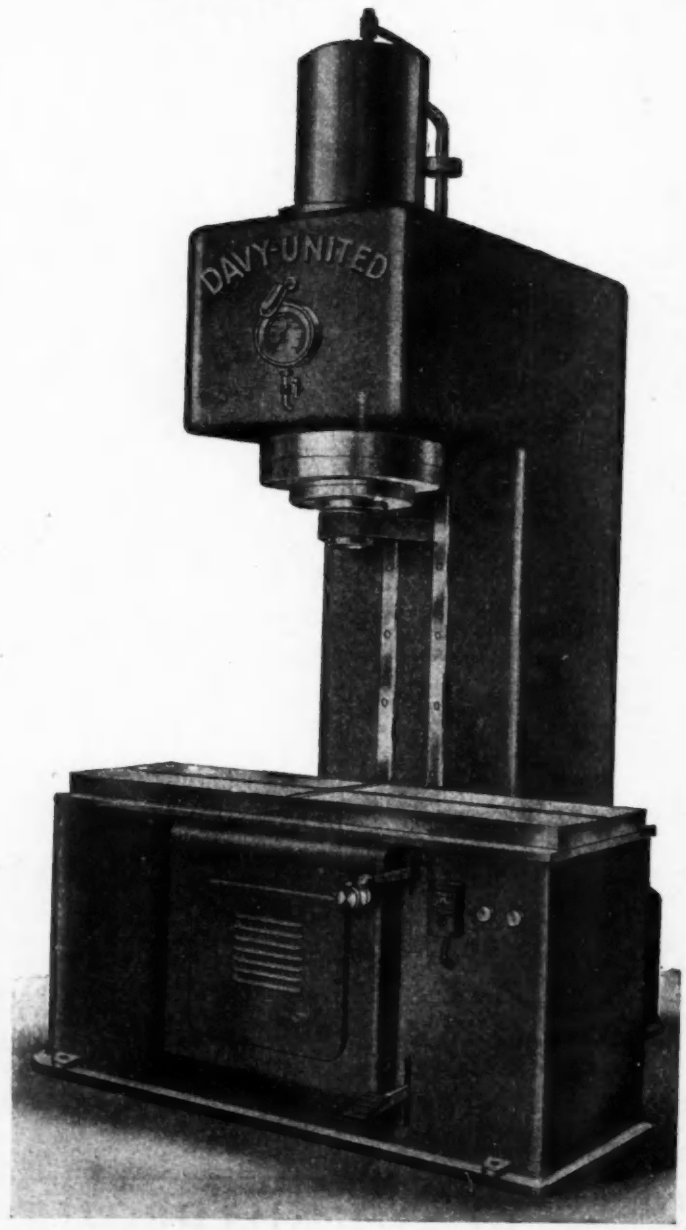

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EXPLOSION OF A SOLID-DRAWN AIR-VESSEL.

By the courtesy of Messrs. British Engine, Boiler and Electrical Insurance Company, Limited, 24, Fennel-street, Manchester, 4, we are enabled to give an account of a careful investigation made by the research engineer to the company, Mr. L. W. Schuster, of the explosion of a solid-drawn air vessel inspected and insured by them. The accident presents some unusual and obscure features, as an examination of the illustrations, Figs. 1 to 9, on this page, on page 556 and on Plate XXX, together with the company's report, will show. The air vessel was of the normal "bottle" type, *i.e.*, a plain cylinder with hemispherical ends, and was of solid-drawn steel. The overall length was 19 ft., the external diameter 12¼ in., and the thickness $\frac{37}{64}$ in. (0·578 in.). It had been hydrostatically tested at the time of manufacture, to a pressure of 3,750 lb. per square inch, and, though it was intended for a working pressure of 2,250 lb. per square inch, it was actually certified for a working pressure of 1,800 lb. per square inch only. The material was specified to have a yield point of 22·25 tons per square inch, an ultimate tensile strength of between 35 tons and 41·25 tons per square inch, and an elongation of 15 per cent. The calculated hoop stress at the interior of the vessel was 8·4 tons per square inch at the stipulated working pressure.

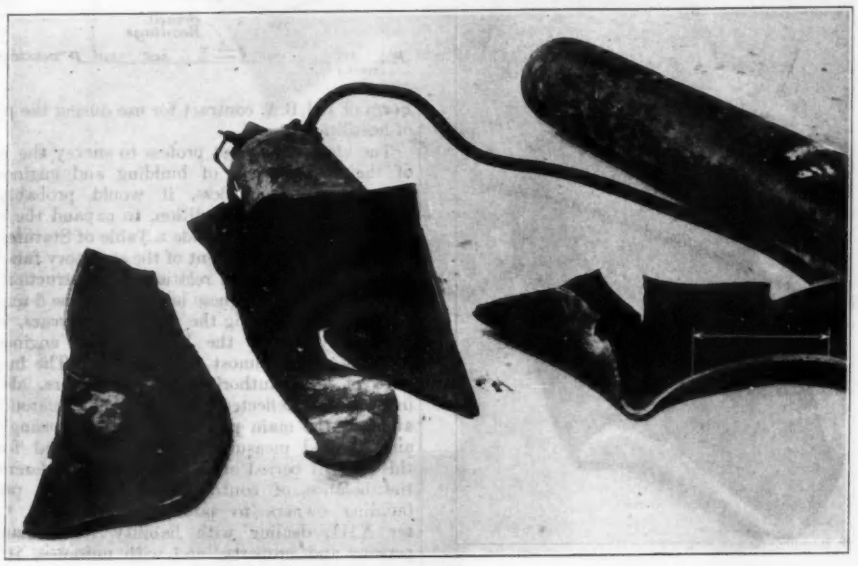


FIG. 1. FRAGMENTS FROM EXPLODED VESSEL.

The vessel acted as a cushioning receiver for the air supply to a cylinder, the piston of which, subject on one side to air pressure, applied pressure to the oil supply actuating a press. The vessel was periodically charged by a three-stage air compressor, the delivery pipe from the compressor being of ¾-in. bore. This pipe was connected to the pipe between the vessel and the cylinder, the latter pipe having an internal diameter of 1 in. The safety valve, which was spring-loaded, was set to blow off at a pressure of 1,600 lb. per square inch, and the accumulation was such that the maximum pressure attainable with the compressor working was 1,875 lb. per square inch. As regards the explosion, according to the information obtained, the vessel had been left charged at the end of a day's run. At 7 a.m. on the following day, when the air compressor was not running and the pressure in the vessel was 1,500 lb. per square inch, the attendant opened the valve on the air vessel connected to the 1-in. pipe. About six seconds afterwards there was a serious explosion, which was heard three miles away. One man was injured and had to be sent to hospital, while considerable damage was done to machinery and surrounding property, 1,000 windows being broken.

The vessel was shattered into four fragments, which, after being collected, were photographed in a group, as shown in Fig. 1, on this page. The largest portion, from which the three other parts were torn, is seen in Fig. 2, page 556. The parts were assembled as accurately as was possible, in view of the considerable amount of deformation they had suffered, and a developed drawing, looking on the inside of the vessel, was made, as shown in Fig. 3, page 556. In this illustration the width represents the circumference of the vessel and the depth represents the affected area, the position of which on the complete vessel is indicated by the letters O O and P P, marked on the outline, Fig. 4, and given at the top and bottom of Fig. 3. The surfaces of fracture were carefully studied, and it was noticed that, in general, failure had occurred in two ways equally characteristic: firstly by shearing, and secondly by ripping. There was no sign of any initial crack. As a result of this study, it was concluded that the initial failure was along the surface somewhere between the points marked A and B in Fig. 3. The markings on the fracture surfaces gave no indication that failure had taken place earlier at any particular point between A and B than at some other point.

At the two positions marked X and X′ in Fig. 3, there was marked evidence of the metal having been bent outwards by the force of the explosion, and the whole appearance between A and B accords with what might be expected when an excessive pressure causes a vessel to bulge along a favourable axis and finally to part there. The line of primary failure is indicated by a small white arrow, on the fragment to which the pipes are connected in Fig. 1, the sharp corner to the left of this arrow being the point X′ of Fig. 3, and the corner farther away at the right hand being the point X. The region of the primary failure is further indicated by a white arrow-headed line on the fragment at the right-hand bottom corner of Fig. 1. This fragment is not readily identifiable in Fig. 3, as a portion was cut from it, which portion afterwards went astray and is indicated by the words "piece missing" in that illustration. The remaining portion, shown in Fig. 3, can, however, be recognised as part of the right-hand bottom fragment of Fig. 1. The arrows in Fig. 3 at right angles to the line of failure show parts that had failed due to internal pressure, while the arrows drawn parallel to the lines of failure represent the direction of the subsequent ripping. At the locality C, between A and B, there was an indentation at the fractured edge. Though, as far as the facts could be ascertained, this indentation was formed at the time of the explosion, it was noticeable that the appearance along its edges did not altogether conform with what might be expected if, during the explosion, the outside of the plate had struck against some extraneous projection and the metal had been cut away by impact. An enlarged view of the indentation is given in Fig. 5, and in the corresponding sketch, Fig. 6, on Plate XXX. Near the outside surface of the indentation the metal was blued and lightly scratched, as if it had been ground.

Gauge readings were taken of the plate thickness, especially in the region of the fractures. These readings are indicated in Fig. 3, and confirmed, in a marked manner, the inferences drawn from the appearance of the surfaces of fracture. At all parts appearing to have been broken by initial bulging to the point of bursting there had been a considerable reduction in the thickness, this reduction being appreciably less at parts considered to have failed by ripping. It is to be observed that the thinnest section lay in the region of the indentation C, and it is to be presumed, therefore, that some such point coincided with the position at which the bulging and stretching of the metal, prior to the first parting of the metal, had been greatest. It is, however, a curious coincidence that this position of greatest bulging should be the very part to strike an obstacle and to be torn off. The opposite surface of fracture was on the missing piece and was not available for examination, but, prior to the disappearance of the piece, it had been photographed. This photograph is reproduced in Fig. 7, Plate XXX. The primary failure was along the edge at the right-hand side, the lower part of this edge, which shows up more brightly than the rest, indicating the region of failure. The part which would appear to have lain opposite to the indentation C is indicated in Fig. 7 by black lines, the width between which is marked by an arrow-headed line. The region of the centre of the bulge is likewise at this point. As far as can be made out in the original photograph, the fracture was perfectly normal.

It was noticeable that the inner surface of the vessel showed Lüders lines in the vicinity of the primary failure. The greater portion of this part, *i.e.*, between the letters M and N in Fig. 3, was accordingly etched in acid to develop the lines for photographic purposes. The angular dotted line across the part in Fig. 3 indicates the top of the view forming Fig. 8, this view representing an etched portion. In the original photograph, the Lüders lines show up fairly well, but in our half-tone reproduction they are necessarily less distinct. The right-hand edge in Fig. 8 is that of the fracture, the curved bottom edge is the saw cut seen in Fig. 3 at the centre of the indentation, while a portion of the indentation can just be made out at the bottom left-hand corner. The position occupied by the Lüders lines is indicated by cross-hatching in Fig. 3, the portion below the saw-cut previously referred to being left unetched. It will naturally be realised that Lüders lines are only to be expected on metal having a suitable surface when that metal has been deformed beyond the yield point. The significant fact is, however, that their distribution in this vessel is consistent with the conclusion that the first area to fail lay in the region of C in Fig. 3. Though the lines are plentiful at the mid-width of the fragment, the reason for this is that the metal there, after the first moment of parting, had been bent outwards until it was practically flat.

TABLE I. *Hardness Tests of Plates.*

Position of Section on Fig. 3.	Outside Surface of Plate.	Inside Surface of Plate.	Mid-thickness of Edge.
Through indentation C—			
Close to indentation ..	187	189	—
7 in. from indentation ..	174, 179	174, 174	179, 179
14 in. from indentation ..	174	174	—
Through *x x*, close to P P ..	170, 170	170, 170	174, 174
Through *y y*, close to O O ..	179	179	174
Through *z z*, near P P normalised	156, 156	156, 153	156, 159

Brinell tests on specimens cut from a part near to, and a part away from, the middle of the burst, respectively, gave the results shown in Table I. It will be seen that, if a reading of 170 is taken to represent the surfaces of the plate and one of 174 to represent cross-sectional readings, it follows that the metal had become slightly hardened at the bulge, and rather more so at the middle of the bulge, at which part the metal had been considerably attenuated and had finally failed. A like degree of work-hardening of the metal is only to be expected after such an occurrence. It is noticeable that appreciably lower hardness figures were obtained

from normalised specimens, similar sets of figures being obtained after two different rates of cooling. The comparatively high figures given by the as-received metal presumably resulted from cold work during manufacture, but no ill effect is ascribed to this work.

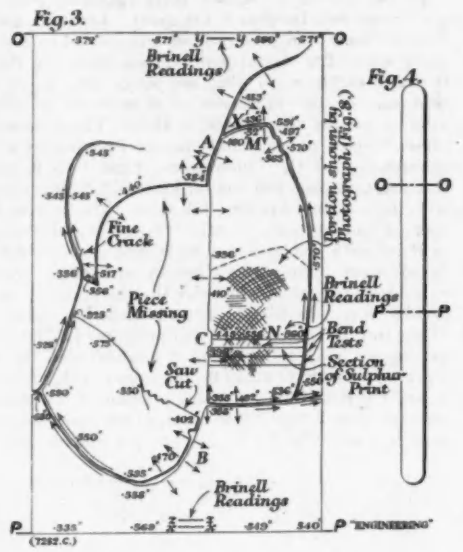
Bend tests were made on curved strips of metal cut out transversely from near the indentation C, as shown in Fig. 3. The specimens had a width of three times their thickness. Specimen 1 was bent inwards, so as to put the outside surface (of the vessel) in tension, the first fine cracks appearing when the specimen attained an inside diameter equal to 2·11 times its thickness. It was estimated that this test was equivalent to bending a flat bar round a "former" having a diameter equal to 2·75 times the plate thickness. Specimen 2 was bent outwards, so that it was first straightened and the curvature then reversed, the inside surface (of the vessel) being thus put into tension. The first cracks appeared when the specimen attained an inside diameter equal to 2·79 times its thickness. It was estimated that this test was equivalent to bending a flat bar on a "former" with a diameter equal to 2·125 times the plate thickness. Repeat tests for other similar strips slightly farther away from the indentation gave rather better results, those for the first cracking being equivalent to bending a flat bar to an internal diameter of 1·75 times the thickness for either direction of bending. In view of the hardness of the material and the fact that the surfaces of the specimens were not dressed before test, these results must be looked upon as satisfactory. Moreover, as the material had been cut from a part that had been both extended and deformed, it had received a measure of cold work at the time of the explosion. In addition, the metal in the neighbourhood of specimen 1, bent inwards during test, had been bent outwards at the time of the explosion, and in the estimate of the severity of the test, no cognisance had been taken of this greater initial diameter or of the work-hardening of the surface owing to its having been compressed before test, and, at the beginning of the test, restored to the original diameter of the vessel.

Under the microscope, the metal in the neighbourhood of the bulge and elsewhere was found to be reasonably clean, and free from threads of drawn-out non-metallic inclusions. The carbon content appeared to be about 0·3 per cent., and the grain size of the ferrite was reasonably small. The pearlite near the inside surface of the vessel was heavily banded and elongated, these features decreasing towards the outside surface. No abnormality was found. In a normalised specimen the pearlite at the interior of the vessel was still banded, but in the form of equi-axed grains; the size of the ferrite grains was slightly reduced. A sulphur print of a cross-section was taken at the point indicated in Fig. 3. This section extended to the primary failure at the indentation C and the part of the print near the indentation is shown in Fig. 9, Plate XXX. The print indicates an absence of sulphur segregation in the metal and shows, at the extreme left-hand, the thinning of the metal in the neighbourhood of the primary failure, this part of the print terminating in the actual fracture. The right-hand portion of the illustration extends to about the middle of the actual print only, and shows, between the two points marked with black arrowheaded lines, the flattening of the shell at the area at which the Lüders lines were particularly conspicuous. Examination of the interior of the 1-in. pipe near the outlet of the air vessel gave definite evidence of the presence of oil that had leaked past the piston of the press, a sooty deposit being discovered in addition. The gun-metal disc of the valve on the vessel at the end of the pipe was missing after the accident, but the valve spindle itself, near the seating, had a sooty deposit and at the far end had been blued by heat. A smell of burnt oil had been noticed after the explosion.

The conclusion reached by the investigation is as follows: The degree of bulging of the plate at the primary failure, the amount of subsequent deformation and the appearance of the surfaces of fracture in no way suggest that the metal was faulty. The whole evidence is consistent with a conclusion that the vessel had been subjected to an excessive internal pressure. Though it was established that

EXPLOSION OF A COMPRESSED-AIR RESERVOIR.

FIG. 2. EXPLODED VESSEL.



ignition had taken place within the piping exterior to the air vessel, no trace of carburised oil or other sign of an internal explosion could be found within the vessel itself. The oil had a flash point of 327 deg. F., but the manner in which ignition took place was not definitely established. To prevent a recurrence of the accident, compressed nitrogen is now employed instead of compressed air.

LITERATURE.

The Law Relating to Building and Engineering Contracts. By W. T. CRESSWELL, K.C. Third edition. London: Sir Isaac Pitman and Sons, Limited. [Price 16*s.* net.]

THE building and engineering industries are not too well catered for by legal authors, who tend to produce either indigestible tomes of somewhat haphazard arrangement, or to err in the opposite direction of undue scrappiness. This work constitutes a happy medium. Convenient in length and of pleasing format, it is systematically arranged on a logical plan so as to serve as a ready guide for the parties concerned in a contract, including the building owner himself, from its inception until after its termination. The last four chapters are of special significance for the engineer, who will find in them a useful summary of his rights and duties, designed to meet the needs of the layman rather than of the practising lawyer. This, the third edition, brings the subject-matter up to date by the inclusion of the amended 1939 Standard Form of R.I.B.A. contract for use during the period of hostilities.

The author does not profess to survey the whole of the vast subject of building and engineering contracts; nevertheless, it would probably be advisable, in a future edition, to expand the scope of the book so as to include a Table of Statutes and a more detailed treatment of the statutory functions of local authorities in relation to construction and demolition works. These have undergone a remarkable extension during the past twenty years, which profoundly affects the building and engineering industries from almost every aspect. The importance of local authorities as contractors, also, is inadequately reflected; while specific reference to, at least, the main provisions of the Housing Acts and kindred measures is certainly called for, in this present period of an increasing transference of the balance of contracting power from private building owners to public undertakers. Chapter XIII, dealing with liability for damage to persons and property, and with nuisance, is concerned with a topic the importance of which is still insufficiently appreciated by many engineers, despite the growing volume of litigation under this head. Chapter XII, too, deserves special notice as providing a useful bird's-eye view of the complexities of arbitration; for the development of that section of British law the engineer can make useful contributions out of the fund of his practical experience.

Engineering Materials. By PROFESSOR A. H. WHITE. London: McGraw-Hill Publishing Company, Limited. [Price 30*s.*]

RECENT developments in relation to engineering materials seem to promise still further and more rapid advances, but, although much theoretical research of high quality continues to appear, the striking practical advances in knowledge come from the experimental laboratory, and much literature has been published on the wider aspects of the materials used in engineering operations. In the present volume the author confines the text to the study of the properties of constructional materials.

The major portion of the book is devoted to the various aspects of ferrous and non-ferrous alloys and, as their composition is bound up so intimately with the processes of manufacture, consideration is given to manufacturing procedure in order to ensure a better understanding of commercial specifications. The historical development of steel manufacture is traced and it is shown how, within fairly recent years, the application of the electric furnace for steel making has reduced the output of crucible steel to negligible importance. By far the greatest part of American steel is produced by the basic open-hearth process, which accounted for nearly 84 per cent. of the total of 47¼ million tons in the

EXPLOSION OF A COMPRESSED-AIR RESERVOIR.

(*For Description, see Page* 555.)

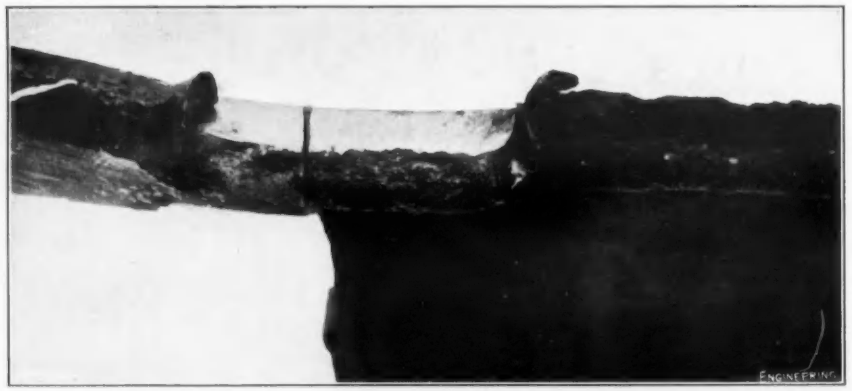


FIG. 5. INDENTATION AT POINT "C" IN FIG. 3 (PAGE 556).

FIG. 7. FRAGMENT SHOWING POSITION OF PRIMARY FAILURE.

Fig.6.

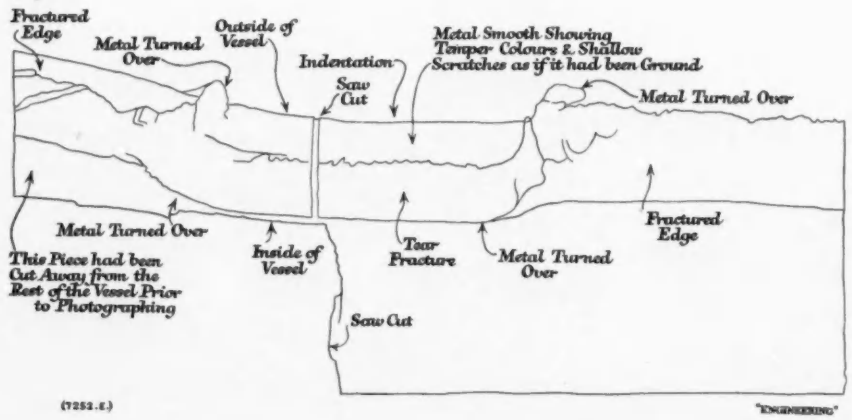


FIG. 8. ETCHED PORTION OF SAWN-OFF FRAGMENT.

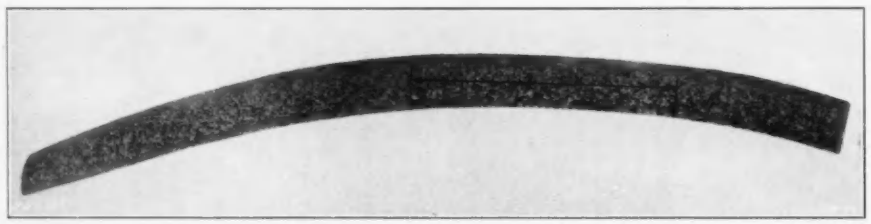


FIG. 9. SULPHUR PRINT IN REGION OF PRIMARY FAILURE.

(*To face page* 556.)

year 1929. Subsequent output, of course, has dropped considerably.

Important sections of the text deal with the changes in the properties of steel due to the operations in the steel mill and in the production of various types of castings. Recently, centrifugal castings have been developed to a point where transmission and ring gears can be cast of a quality superior to those formerly produced by forging. In dealing with corrosion phenomena in relation to metallic surfaces, the author shows a clear appreciation of the intricate problems involved. There is no single cause of corrosion, and it can be explained only by a comprehensive study of individual cases. The later sections of the volume deal with clay and plastic products. Two final chapters devoted to the industrial utilisation of water and fuels appear to be somewhat out of place, although these are, no doubt, "engineering materials" in the economic sense. Incidentally, the text of these chapters lacks the lucidity which is characteristic of the other sections of the volume. The extensive use of equilibrium diagrams throughout the book is a valuable feature.

Civil Defence. By C. W. GLOVER. Second edition. London: Chapman and Hall, Limited. [Price 36s. net.]

ALTHOUGH the means of obtaining protection from air attack have been studied for many years, it is only comparatively recently that practical civil-defence measures have been enunciated. The rapid development of methods of attack have induced corresponding schemes of protection, and, not unnaturally, a considerable literature has grown up with it. Usually, the more serious works have been based on information published by the Air Raid Precautions Department of the British Home Office, by the corresponding authorities of other Governments, and by committees of experts appointed by various professional bodies. This course has been followed by the author of the present volume, but he has added material from his own knowledge and experience as an engineer, and thus has produced a very useful and comprehensive treatise. Although the trained engineer who has made any study of air raid precautions will be familiar with much of its contents, he will find, conveniently at hand, useful data gathered from many sources.

Some of the material, reprinted from the first edition, has apparently escaped revision to bring it into line with up-to-date technique. For example, on pages 63 and 64, the reader is warned against spraying water on to a burning magnesium incendiary bomb, though, on page 75, his close attention is directed to A.R.P. Handbook No. 9, in which water sprayed on to the bomb from a stirrup pump is advised. On page 100, the height of sandbag or other protective walling is recommended to be about 5 ft. above internal floor level; this dimension should be a minimum of 6 ft. There appears to be a typographical error in the kinetic-energy formula, new in this second edition, at the top of page 57; the factor 2M should be the divisor.

The chapter on "Buildings" is mainly a reproduction of that in the first edition, but some useful new matter has been collected in the next chapter, on "Strengthening Existing Buildings." These two chapters form a good guide to the principles to be taken into account. Then follow chapters on shelters and trenches. The chapter on "Bomb-Proof Shelters" is mainly new, as is also that on "The Statutory Basis of A.R.P." The treatment of camouflage is a good presentation of this science and art, while the chapter on "A.R.P. in Factories" brings out the main points to be watched. Emphasis should be laid on the importance of the principles of siting shelters and on the precautions to be taken to prevent emergency exits from becoming blocked with debris. While this book will help practically-minded people in constructing the simpler types of shelter, the specialist will still be needed in works of a more important nature, particularly the adaptation of existing structures. A glossary of technical terms is given; but, because this book has been written largely for the layman, all the technical terms appearing in its pages should have been included in the glossary. The index, though good, could be made still more serviceable by further sub-division.

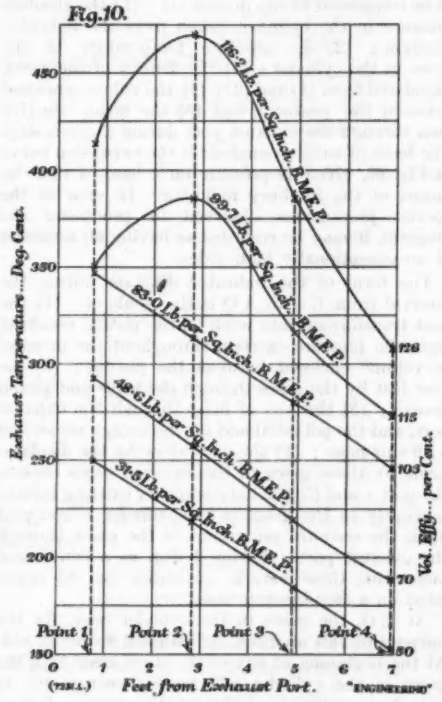
AN ANALYSIS OF CERTAIN CHARACTERISTICS OF A KADENACY ENGINE.

By PROFESSOR S. J. DAVIES, D.Sc., M.I.Mech.E.

(*Continued from page* 517.)

A FURTHER factor to be taken into account is that, of the air charge taken in, a portion may pass through to the exhaust without taking part in the combustion. This is to be expected from the high value of the volumetric efficiency measured, but other evidence for this may be found in Fig. 10, below, which shows the mean temperatures observed by placing a mercury thermometer in the exhaust pipe at four measuring points, 1, 2, 3 and 4, at distances, respectively, of 9 in., 34 in., 59 in. and 83 in. from the exhaust port. Five curves are shown on this figure, all taken at 1,282 r.p.m., and with the values of B.M.E.P. also shown. The measured values of the volumetric efficiency at these values of B.M.E.P. are given on the right. It cannot be contended that these temperatures are accurate mean values, since the fluctuations of temperature at these points during a cycle take place extremely rapidly, and are very irregular in character. Nevertheless, as comparative values they are useful. In the lowest three curves there is a consistent rise of temperature at measuring point 1, nearest the cylinder, with increase of load, and increase in volumetric efficiency, but in the two upper curves there is inconsistency in the readings at this point, the temperatures shown being much lower than would be expected from the trends of the respective curves. The lower values can only be attributed to the effect of cold air passing through the cylinder and out of the exhaust port to the measuring point during the charging period, this cold air having but a small direct effect at the next measuring point 2, and a still smaller effect beyond 2. That cold air passes into the exhaust pipe in the test forming the subject of this analysis is, therefore, clear, and it remains to be seen how much air is finally retained in the cylinder.

Fig. 10.



A check on the relationship of the temperatures in the cylinder at A C and E O on Figs. 6*a* and 6*b*, page 516, *ante*, may be made as follows: At A C, the contents of the cylinder consist of the air that remains in the cylinder; at E O the exhaust gases forming the cylinder contents consist of this air together with the fuel charge. The volumes enclosed between the pistons at E O and A C are 583 c.c. and 600 c.c., respectively. At E O, the absolute pressure in the cylinder is 74·7 lb. per square inch, while at A C the pressure is 17·2 lb. per square inch. Assuming that the air to fuel ratio for combustion is 23 to 1, which is reasonable in view of the B.M.E.P. of 116·2 lb. per square inch; that the physical properties of the resulting cylinder contents at E O lead to a value of R, the gas constant, equal to 92·2 ft.-lb. per lb. per deg. C.; and that the cylinder contents at A C consist of pure air, giving R equal to 96·0, it is possible to obtain a rough relationship between the absolute temperatures at these points. Let T_{EO} and T_{AC} be the absolute temperatures at E O and A C, respectively. Then at E O,

$$T_{EO} \propto \frac{P \,.\, V}{(23 + 1) \,.\, R} = \text{constant} \,.\, \frac{74{\cdot}7 \,.\, 583}{24 \,.\, 92{\cdot}2};$$

and at A C,

$$T_{AC} = \text{constant} \,.\, \frac{17{\cdot}2 \,.\, 600}{23 \,.\, 96{\cdot}0}.$$

$$\frac{T_{EO}}{T_{AC}} = \frac{74{\cdot}7}{17{\cdot}2} \cdot \frac{23}{24} \cdot \frac{96{\cdot}0}{92{\cdot}2} \cdot \frac{583}{600} = 4{\cdot}21,$$

that is, the temperature at E O is rather more than four times that at A C. This relationship depends only slightly on the assumed air to fuel ratio.

In order to arrive at a reasonable figure to assume for the temperature of the cylinder contents at E O, consideration must be given to three points. Firstly, from the temperature and the indicated pressure, the density of the charge can be calculated, and from this the mass of gas enclosed between the pistons may be found. The difference between this mass of gas and the total charge of air per cycle, 0·00235 lb., gives the proportion of the air charge that must have passed through the cylinder into the exhaust system. The proportion left, which receives the full charge of fuel, must be sufficient to give the measured B.M.E.P. Secondly, the air to fuel ratio of the charge must be reasonable. Thirdly, since the temperature at A C is 1/4·21 of that at E O, the value chosen for E O must lead to a suitable figure at A C. Taking all these conditions into account, it was decided to take 1,300 deg. C. abs. as the temperature at E O.

This temperature gives the mass of air and fuel enclosed at E O as 0·001849 lb., which means that a proportion of 75·4 per cent. of the total air charge is retained or trapped in the cylinder; this, in its turn, gives a "trapped" volumetric efficiency of 95·0 per cent. In view of the results generally observed in four-stroke engines, where a B.M.E.P. of 100 lb. per square inch is associated with volumetric efficiencies of the order of 90 per cent., this figure is reasonable for the B.M.E.P. of 116·2 lb. per square inch measured. The corresponding air to fuel ratio is 75·4 per cent. of 30 to 1, or about 23 : 1, agreeing with the ratio assumed above. Lastly, the corresponding temperature at A C is 309 deg. C. abs., a rise of 16 deg. C. from the atmospheric value of 20 deg. C. This is a small rise, but, at 1,282 r.p.m., is consistent with the complete evacuation of the exhaust gases necessary to give the volumetric efficiency of 126 per cent. measured, and the trapping of a pure charge of atmospheric air at A C. It is a low value for the temperature at the beginning of compression, and will lead to a corresponding reduction in the temperature throughout the cycle, which is an advantage in view of the high B.M.E.P. Altogether, the evidence in support of the assumed figure of 1,300 deg. C. abs. is satisfactory.

Having reached this point, we are faced with the most important question: on what basis is the transformation of the energy of the gases in the cylinder into the kinetic energy of the gases passing through the exhaust port to be considered? Reference to books on internal-combustion engines shows the most advanced treatment to be that in *Dieselmaschinen*, page 210, by the late Professor Magg. In this treatment, based on the principles of steady flow from a reservoir, as given by Schüle (*Technical Thermodynamics*, page 215), the exhaust from the cylinder is considered as flow from a vessel through an orifice of varying time-area. The flow is further assumed to take place with a fall of pressure from the cylinder pressure to the port pressure, and from the port to the back pressure, which is atmospheric pressure, the port pressure being that at the smallest cross section of the stream—that is, the "throat" pressure. So long as the ratio of the back pressure to the cylinder pressure is less than the critical value, the gases are considered to flow through the port with the

speed of sound in the medium under the conditions prevailing at the port. Below the critical ratio, the rate of mass discharge depends only on the speed of sound and on the effective area of the port or throat. When the pressure ratio is greater than the critical value, the outflow is less, and then depends upon the pressure difference. Throughout the discharge, the expansion of the gases is assumed to be continually resisted, and the conditions throughout are considered to be strictly adiabatic or isentropic. In effect, Magg made a separate calculation for each of a large number of values of diminishing cylinder pressure and increasing port area, assuming a constant back pressure equal to 1·05 (atmospheric pressure), and he then integrated these over the exhaust period. The condition of the gas at any instant, and at any point in the discharge, was assumed to be the same as would be the case in steady flow from a region of high pressure to one at constant low pressure through a suitably shaped nozzle, as is assumed, for example, in an impulse steam turbine.

Upon examination, it is seen that this treatment is incomplete in connection with the present analysis, since it does not take into account the following circumstances: the rapidity of the changes in the area of the cross section of the port; the rapid changes in the pressure in the cylinder; the relatively small volume of the cylinder compared to the area of the port; the motion of the gases in the cylinder; and the motion and pressures of the gases external to the port. Given a very large volume in the cylinder relatively to the port, and a very slow rate of opening of the port, then the conditions approach those of continuous flow, such as would take place from a reservoir of infinite volume through a port of finite area. At the other extreme, if the port opens instantaneously to an area large in relation to the volume of the cylinder, then, as soon as the port is opened, but before motion of any kind can begin, there is discontinuity between the cylinder pressure and the external pressure. The actual conditions in the engine under test probably lie somewhere between these two extremes, as regards the rate of opening of the port, and the relation of the area of the port to the volume of the cylinder.

Preliminary calculations of the momentum passing point P, Fig. 8, page 516, *ante*, showed that the velocities through the ports are very high, at least during the first 10 deg. after E O. For these high velocities through the ports, there must be high velocities of approach in the cylinder, corresponding to the displacement of the mass of gas involved, and these velocities of approach will exert an influence on the exhaust process, whereas Magg's treatment assumes the general mass of gas in the cylinder to be at rest. The treatment further assumes that the gases passing out of the port can expand freely beyond the port, and pass away into the atmosphere. This is not true for, however short the exhaust pipe, the gases leaving the port possess direction as well as velocity, and, during the exhaust process, must impinge upon the external gases and set them in motion. This action involves some increase of back pressure. In an engine, an exhaust pipe of some length must be provided in order to convey the gases away. That the resistance due to the back pressure can soon become appreciable is shown by the pressures recorded at P, and shown in Fig. 9, page 516, *ante*. Point P is only some 4 in. from the exhaust ports and the area of cross section of the pipe at P is, up to 13 deg. after E O, much more than twice the area of the port, so that the gases should, according to the treatment, continue to expand from the port to point P. The values of the pressure recorded at P show that such a free expansion of the gases from the port outwards cannot be assumed in this case.

It must be concluded that, during the exhaust process, and more especially during the first 21 deg. after E O, the pressures, temperatures, specific volumes, and velocities of the gases are all changing rapidly from instant to instant, and the conditions controlling the inter-conversion of heat energy and mechanical energy in the exhaust gases, on the one hand, and the interchange of momentum between these gases and the external gases, on the other hand, are much more involved than those in Professor Magg's treatment. The author has sought other treatments which would take account of the rapid variations in the conditions, but without success, and is compelled therefore to confine himself to his own experimental data. Using these data, and considering, from instant to instant, the energy still remaining in the cylinder and that conveyed away by the gases issuing from the exhaust port, he has calculated the pressures, temperatures, and velocities necessary for continued equilibrium between the energy in the cylinder and that lost externally.

Taking 1,300 deg. C. abs. as the temperature of the cylinder contents at E O, and 0·001849 lb. as the corresponding mass of these gases, it is possible, by considering the quantities of energy lost from the cylinder and those quantities of energy remaining in the cylinder, and by forming equations from these, which may be solved by step-by-step calculations, to analyse the movements of the gases during the period from E O onwards. In particular, the interval from E O up to A C, and perhaps a little beyond, is of importance, since, during this interval, the passage of the gases out of the cylinder through the exhaust port is not influenced by the entry of gases through the admission port. The variables to be considered at any instant are: (1) the absolute pressure in the cylinder, taken from the indicator diagram; (2) the absolute temperature of the gases in the cylinder; (3) the density of the gases, calculated from (1) and (2); (4) the volume enclosed between the pistons; and (5) the mean effective area through the exhaust port during a given step. The basis of such an analysis is the expansion curve in Fig. 6*b*, given as pressure on a base of time by means of the Sunbury indicator. In view of the special precautions observed in producing the diagram, it may be regarded as having an accuracy of an exceptionally high order.

The form of the indicator diagram during the interval from E O to A O is the result of: (1) the heat transformed into work on the piston, resulting from the pressure exerted, throughout the increase in volume enclosed between the pistons; (2) the heat lost by the gases through the walls and piston crowns; (3) the loss of mass through the exhaust port, and the potential and kinetic energy associated with this mass; (4) the work done by the displacement by these gases of the external gases outside the port; and (5) the kinetic energy existing instantaneously in the gases in the culinder consequent upon the outward mqvement of the gases through the exhaust port. Taking 1 deg. as a convenient increment, these various quantities can be calculated on a step-by-step basis.

At E O, the gases in the cylinder may, for the purpose of this analysis, be assumed to be at rest. At the beginning of any of the steps after E O, the gases in the cylinder will possess energy due to their temperature, and also kinetic energy. During the step, energy will be lost externally from the cylinder: (1) in work on the pistons; (2) as heat to the walls and the piston; (3) as pressure and potential energy in the mass which has passed out through the exhaust port; and (4) as kinetic energy in this mass. Other changes of the energy in the cylinder may follow from an increase or decrease in the kinetic energy of the gases remaining in the cylinder. The total energy in the gases in the cylinder at the end of a step is equal to the total energy in the gases in the cylinder at the beginning of the step, minus the energy which has been lost externally during the step.

The total energy of a unit mass of gas is represented by

$$\frac{P\,V}{J} + C_v \,.\, T + \frac{1}{J} \cdot \frac{v^2}{2\,g},$$

where

P = pressure,
V = specific volume,
T = absolute temperature,
v = mean linear velocity, and
C_v = specific heat at constant volume.

Of this energy, however, only the second and third terms may be utilised in expansion from a closed vessel. The general expression may be re-written as

$$\frac{R\,T}{J} + C_v \,.\, T + \frac{1}{J} \cdot \frac{v^2}{2\,g},$$

or

$$C_p \,.\, T + \frac{1}{J} \cdot \frac{v^2}{2\,g},$$

where R is the gas constant, and C_p is the specific heat at constant pressure. It is now possible to produce the energy equation in the following manner: Let W_1, W_2 represent the masses of gas in the cylinder at the beginning and end of the step, respectively, and T_1, T_2 the corresponding values of the absolute temperature; v_1, v_2, the mean velocities in the mass of gas in the cylinder; t_1, t_2, the absolute temperatures at the port at the beginning and end of the step; v, the mean velocity of the gases passing through the exhaust port during the step; and H, the heat lost to the walls and pistons during the step. The equation is then:

$$\underset{\text{I.}}{W_1 C_v T_1} + \underset{\text{II.}}{\frac{4}{3} \cdot \frac{1}{2g} \,.\, W_1 v_1^2 \frac{1}{J}} = \underset{\text{III.}}{W_2 C_v T_2}$$

$$+ \underset{\text{IV.}}{\frac{4}{3} \cdot \frac{1}{2g} \,.\, W_2 v_2^2 \frac{1}{J}} + \underset{\text{V.}}{(W_1 - W_2) C_p \left(\frac{t_1 + t_2}{2}\right)}$$

$$+ \underset{\text{VI.}}{\frac{W_1 - W_2}{2g} \,.\, v^2 \,.\, \frac{1}{J}} + \underset{\text{VII.}}{\int P\,d\,V \,.\, \frac{1}{J}} + \underset{\text{VIII.}}{H}.$$

For convenience, each term in the equation is marked by a Roman numeral above it.

Terms I and III of this equation represent the potential energy of the gases in the cylinder at the beginning and end of each step. Terms II and IV represent the kinetic energy of the mass of gas in the cylinder, where v_1, v_2 are the mean velocities of the centre of mass, the distribution of velocity being taken as linear from 0 to 2 v_1 and to 2 v_2, respectively. Term V represents the energy (potential energy + work done) of the gas ($W_1 - W_2$) escaping from the cylinder during the step. Term VI represents the kinetic energy of the gas ($W_1 - W_2$) escaping from the cylinder during the step with a mean velocity v through the port. Term VII represents the work done by the gas in the cylinder on the pistons during the step. Term VIII represents the heat lost by the gases in the cylinder to the walls during the step, and is estimated to be one-quarter of the work done during the step, as obtained from the indicator diagram, so that terms (VII + VIII) $= \frac{5}{4}$. (work done). It will be found convenient for the solutions to transpose terms III, VII and VIII, and the equation may now be re-written:

$$\underset{\text{I.}}{W_1 C_v T_1} - \underset{\text{III.}}{W_2 C_v T_2} + \underset{\text{II.}}{\frac{4}{3} \cdot \frac{1}{2g} \,.\, W_1 v_1^2 \frac{1}{J}}$$

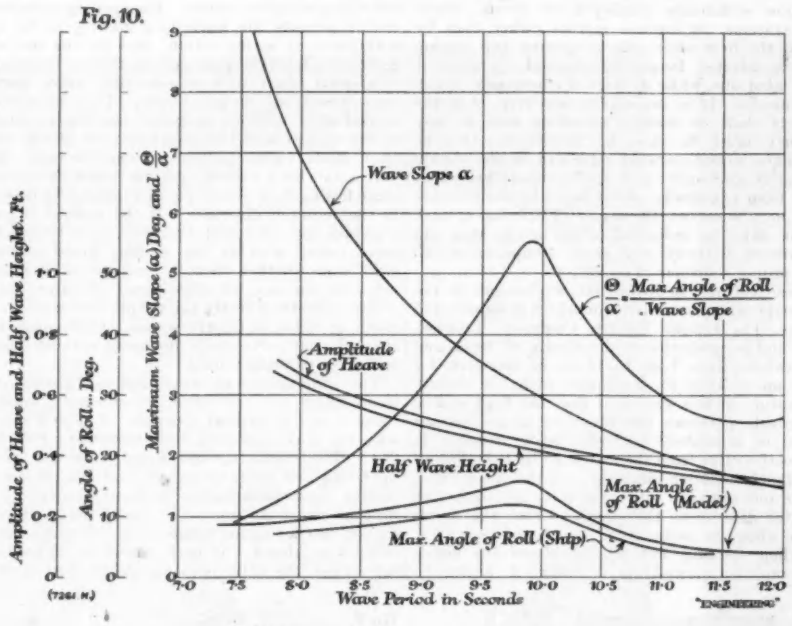
$$- \underset{\text{VII + VIII.}}{\left(\frac{5}{4} \int P\,d\,V \,.\, \frac{1}{J}\right)} = \underset{\text{IV.}}{\frac{4}{3} \cdot \frac{1}{2g} W_2 v_2^2 \frac{1}{J}} +$$

$$\underset{\text{V.}}{(W_1 - W_2) C_p \left(\frac{t_1 + t_2}{2}\right)} + \underset{\text{VI.}}{\frac{W_1 - W_2}{2g} \,.\, v^2 \,.\, \frac{1}{J}}.$$

There is one relationship in this equation that is still indefinite, namely the relationship existing between t, the temperature at the throat, at any instant, and T, the corresponding value of the absolute temperature of the gases in the cylinder. While the general mass of gas in the cylinder is expanding, as a result, on the one hand, of the increase of volume between the pistons, and, on the other hand, of the loss of gas passing out through the port, there may, or may not, be an expansion of the gas from the interior of the cylinder to the port. The relationship between t and T will depend upon the extent of the second kind of expansion. While it is to be expected that, when flow has been established, the expansion may be adiabatic, on the other hand, immediately upon the sudden opening of a port, the gases may pass out without expansion, under their molecular velocities. These two extreme cases have been considered, and the

ROLLING EXPERIMENTS WITH SHIPS AND MODELS.

Fig. 10.


Wave Slope α
Θ/α = Max. Angle of Roll / Wave Slope
Amplitude of Heave
Half Wave Height
Max. Angle of Roll (Model)
Max. Angle of Roll (Ship)
Amplitude of Heave and Half Wave Height...Ft.
Angle of Roll...Deg.
Maximum Wave Slope (α) Deg. and Θ/α
Wave Period in Seconds
(72a 8)
"ENGINEERING"

effects upon the relationship between t and T would be: (1) with adiabatic expansion,

$$t = \left(\frac{2}{\gamma + 1}\right) T,$$

where γ is the adiabatic index; and (2) with no expansion, $t = T$. Calculations followed these two sets of conditions.

Under the conditions of pressure and temperature of these gases, the following constants are used, as representing general average values: $C_p = 0{\cdot}2852$; $C_v = 0{\cdot}2162$; $\gamma = 1{\cdot}32$; and $R = 92{\cdot}2$ ft.-lb. per lb. per deg. C. The pressure in lb. per square inch is denoted by P, and V is the volume enclosed between the pistons relative to the volume at E O (V_{EO}). The volume enclosed between the pistons at exhaust opening is 583 c.c., or 0·0206 cub. ft., and it is possible to express all corresponding volumes in terms of the volume of E O as unity. W_1, and x ($= W_1 - W_2$) are the masses of gas, in lb.; and A is the mean port area in square feet during the step. With the aid of these constants, the equation may be converted to one in which the only unknown is $(W_1 - W_2) = x$, as follows: Using P V = W R T, terms I and III are converted to the form constant, P V. Term II is always term IV of the previous step. In term IV, the velocity v_2 depends directly on $(W_1 - W_2)$, that is, on x, and inversely, on W_2, and $W_2 = (W_1 - x)$. W_2 depends directly on the volume V_2 enclosed between the pistons, and on the density of the gas. Term IV may thus be expressed in the form:

$$\text{constant} \cdot \frac{V_2^2 x^2}{(W_1 - x)}.$$

In term V, $(W_1 - W_2) = x$, and $t_1 = \text{constant} \cdot T$, that is,

$$t_1 = \text{constant} \cdot \frac{P_1 V_1}{W_1};$$

t_2, similarly

$$= \text{constant} \cdot \frac{P_2 V_2}{W_2},$$

so that term V can be reduced to the form:

$$\text{constant} \cdot \left(\frac{P_1 V_1}{W_1} + \frac{P_2 V_2}{W_1 - x}\right) x.$$

In term VI, $(W_1 - W_2) = x$, v depends directly on x, inversely on the mean density at the throat, and inversely on the area A through the port, and since it is the mean velocity, term VI can thus be reduced to the form:

$$\text{constant} \cdot \left(\frac{V_1 V_2}{W_1 V_2 + (W_1 - x) V_1}\right)^2 \frac{x^2}{A^2}.$$

For the case where $t = 0{\cdot}864$ T the equation becomes:

I. $0{\cdot}00696\, P_1 V_1$ − III. $0{\cdot}00696\, P_2 V_2$ + Term IV of previous step.

VII. + VIII. IV.

$$-1{\cdot}25 \int P \,.\, d\,V = 72{\cdot}6\, V_2^2 \frac{x^2}{(W_1 - x)}$$

V.

$$+ 0{\cdot}00397 \left(\frac{P_1 V_1}{W_1} + \frac{P_2 V_2}{W_1 - x}\right) \frac{1}{2} x +$$

VI.

$$1{\cdot}114 \left(\frac{V_1 V_2}{W_1 V_1 + (W_1 - x) V_1}\right)^2 \cdot \frac{x^2}{A^2}.$$

For the case where $t = T$, the coefficient of term V becomes 0·00459, the other terms remaining unchanged.

(To be continued.)

ROLLING EXPERIMENTS WITH SHIPS AND MODELS IN STILL WATER.*

By R. W. L. GAWN, R.C.N.C.

(Concluded from page 552.)

THESE tests of three different models clearly establish that there is sufficient agreement with the respective ships as regards rolling extinction to render model experiments reliable as a guide to ship behaviour in still water, and to the effect of modifications to hull or bilge keels. The curve of declining angles shows that the differences in extinction are not such as substantially to influence the rolling of the ship. It is clear that model experiments will give a reliable idea of the safety of the ship when rolling at sea. From the standpoint of theory of rolling, however, the differences between model and ship are important, and the possible causes are examined in detail below.

The surface of the paraffin-wax model is smoother than that of a riveted ship, and the friction element in the damping would be expected to be less to scale in the model. It seems reasonable to assume that there is no frictional wake effect to produce a decline in skin-friction coefficient in the ship as compared with the model, when rolling, similar to the decline in skin-friction coefficient as applied to fore and aft resistance. If such an effect existed, it would tend to exaggerate the difference, but its importance would be minimised by the small part that friction appears to play in the damping. This has been brought out by the small damping effect due to the hull alone, and the comparatively unimportant effect of roughening the model surface. Regard must be paid to the small velocity of roll, namely, about 2 ft. per second at the bilge of the ship for an amplitude of 10 deg. each way, and only about 0·4 ft. per second in the model. There is a hydrodynamic current at the bilge and the maximum relative velocity, therefore, is greater than these figures, which relate to the simple-harmonic velocity. The equivalent Reynolds number is on the small side, however, so that the flow is in the transition zone from laminar to turbulent, probably with a tendency for laminar flow to predominate. As far as the model is concerned, it would appear that differences of condition of surface are not very important. It seems reasonable to conclude that friction contributes only a small portion of the total damping. It would be necessary to assume that the skin-friction coefficient of the ship is 30 times that of the model for the difference from the ship to be explained by differences in friction coefficient.

Such items as superstructures, funnels, deck erections, guns, boats, masts, bridges, rigging, and all weather-deck items and fittings, are omited in the model. The damping effect due to reaction of the air on these items, therefore, is not represented in the model experiments. It is estimated that the damping effect on the rolling of Nubian due to the air resistance of the above-water portion is of the order of one-tenth of 1 per cent. at 10 deg., which is a negligible proportion of the difference between model and ship.

As the bilge keels contribute so large a share of the total extinction, it is natural to suspect that the differences between model and ship might be found in the scale effect of the bilge-keel reaction. Plane experiments at 90 deg. incidence show that both velocity, size and aspect ratio are of importance in determining the resistance coefficient. Experiments at low speed at Haslar indicate that the unital pressure coefficient increases with speed, but there is no investigation relating directly to such long and narrow surfaces as bilge keels which would give definite information. There appear grounds for inferring that differences in bilge-keel reactions between model and ship are a probable cause of the differences in the respective extinction curves. In a perfect fluid it would be expected that the virtual mass would be proportionately the same in ship and model, as they are dynamically similar. Apart from any addition to the virtual mass that may be contributed by the bilge keels, it does not appear that this can explain the results.

For precise comparison, the model rolling experiment should be made in the same corresponding depth of water as the ship trials. Possibly the small increase of extinction in shallow water in the Nubian experiments can be reasonably attributed to greater velocity changes at the bilge as compared with deep water. An attempt was made to observe the surface waves created during the rolling of the model, both in shallow and in deep water, but these proved to be so diminutive as not to be readily susceptible of measurement. The effect of shallow water to increase damping was particularly marked in King George V, where the depth of water was least in relation to the size of the ship. For Vivien, where the depth was greatest in relation to size of ship, there did not appear to be any measurable influence on damping due to the shallowness of the water. Measurement of the small forces due to surface tension was not considered justified. A very rough analysis suggests that surface tension is likely to increase the model extinction not more than one-quarter of 1 per cent. The effect on the ship extinction is negligible.

The model is arranged with the midship section in the centre of the experiment tank and the middle line inclined at 45 deg. in order that the waves created by the rolling motion should have a greater distance to travel before being reflected back on to the model. With the model at 200 ft. from the ends of the waterway the waves have to travel 565 ft. before reaching the model. After being reflected from side to side across the tank and then back again from the end of the waterway, the motion naturally becomes confused. In the case of a model of, say, 2 seconds period, the speed of the individual wave is 10·25 ft. per second, the speed of travel of the wave system is 5·1 ft. per second, and the time required for the waves to reach the model is nearly 2 minutes. The wave echoes, when they return, should be mainly travelling end-on to the model. In a model with bilge keels, the rolling is stilled well before the waves return. In some cases where bilge keels are not fitted, if there is any sign that the rolling has been influenced by recoil waves, the experiment is repeated with a smaller initial angle of roll. Thus the model rolling experiments are free from any influence of recoil waves and are in truly undisturbed water. It is not possible to arrange such ideal circumstances for the ship. The Nubian rolling trials were conducted in a large basin, and the length available for the waves to travel before being reflected back from the sides was about equal to the length of the ship. The maximum effect of the reflected wave is seen by considering the first oscillation, in which the angle of roll was reduced from 7·2 deg. to 5·7 deg.

* Paper contributed to the *Transactions* of the Institution of Naval Architects. Abridged.

The work done, that is, the loss of potential energy, is 22·2 tons-ft. Some (perhaps most) of this energy will be lost in bilge-keel reaction, eddy formation, and surface friction, but assuming that it is all used up in producing a wave of width equal to the length of the ship and length appropriate to the period, namely, 500 ft., then the height of the wave is 2·3 in. From the theory of resisted rolling in synchronous waves, the corresponding forced oscillation of the ship is 0·4 deg. This is an extreme estimate; the actual wave will be less. In aggregate, the effect will be very small. No wave motion was observed during the rolling; neither is there any evidence in any of the records that the motion has been prejudiced by the recoil waves.

It is of interest to ascertain to what extent the behaviour of the ship at sea is influenced by the difference in damping. Rolling experiments among regular waves had been made, as part of the test procedure, when the Nubian design was under consideration, and some of the more apposite results are reproduced in Fig. 10, on page 559. A curve is included showing the maximum amplitude of roll for the ship among waves of the length and height indicated on the diagram. This curve has been deduced from that of the model on the basis of Froude's theory of resisted rolling among waves, and assuming that the resistance of the ship is greater than that of the model by the amount found on the trials. This comparison shows that the maximum angle of roll of the model in the synchronous wave is 16 deg., compared with 12 deg. for the ship. In waves longer or shorter than that corresponding to synchronism, the difference in maximum amplitude of roll between model and ship will be less, and for waves of a period less than 70 per cent. of that of the synchronous wave, or greater than 130 per cent., the differences between model and ship are less than 1 deg. Thus the differences in damping in still water, between model and ship, do not appear to have a striking influence on the angle of roll in regular waves, except in synchronous waves.

No systematic investigation was carried out on the Nubian model or ship as to the effect of ahead motion on the rolling. An estimate can be made, however, from experiments on a recent similar model of comparable type. These show the following values of extinction at rest and at speeds corresponding to 20 knots and 40 knots, respectively:—

	Extinction at 10 deg. $\left(-\frac{d\Theta}{dn}\right)$.	
Speed, knots.	Naked Model.	With Bilge Keels.
At rest	0·22	1·53
20	0·09	2·20
40	1·53	3·38

It is seen that the damping due to naked hull, when under way, increases at a greater rate than that due to the bilge keels. It is inferred that, at 40 knots, the ship would roll about 1 deg. less than if its resistance corresponded to that of the dynamic model. This relates to rolling in a synchronous wave.

A general conclusion from this investigation, covering trials on four different ships and comparison with the rolling tests of the corresponding models, is that the curve of extinction for the ship is fairly well reproduced from the results of a corresponding dynamic model with a smooth paraffin or varnished surface. On the average, the extinction of the model is about 27 per cent. less than that of Nubian, but the difference is less in the case of the three other ships. This may be due to greater roughness of ship's surface or increased bilge-keel reaction on the ship to scale. As regards the former, it has been shown that the increase of skin-friction coefficient required to be assumed in the ship, compared with the model, would seem to be so great as to preclude the possibility of this explanation. Scale effect on bilge-keel reaction appears a more plausible solution, having in mind also the possibility of a greater proportional extent of dead water in the neighbourhood of the model keels, due to the laminar flow. The bilge keels account for about 80 per cent. of the total damping, and for this reason any scale effect is likely to be more important in connection with the bilge forces. Effect of appendages, including propellers and depth of water, must be allowed for in any comparison between model and ship. Air resistance of the ship, condition of the model surface, surface tension and virtual mass do not appear to play important parts. The difference in extinction reacts only to a small extent on the amplitude of roll among waves at rest, and to a still smaller extent when under way. The main disagreement between model and ship is not so serious as to detract from the utility of the model experiments, as a guide to the probable behaviour at sea, and to the best size and position of bilge keels.

THE UNITED STATES STEEL INDUSTRY.—The production of steel ingots in the United States is stated to have been equivalent to 70 per cent. of the capacity of the steelworks in the week ending May 4.

THE DEAN ELECTRIC CONTROL SYSTEM FOR VALVES.

THERE are many advantages in operating the large valves, now commonly employed on steam, water and gas systems, by electric motors rather than by hand. In the first place, where opening and closing have to be effected frequently, manual operation is slow and laborious, while in cases of emergency it may also be unsafe. It is necessary, moreover, that the handwheels shall be readily accessible and, in any event, they must be close to the valve. On the other hand, a motor-operated valve can be placed anywhere that is convenient and can be controlled either locally or from a centrally-placed board by the pressure of a button. Moreover, the degree of opening of each valve can easily be indicated, while interlocking can be introduced without any great complication, to ensure a proper sequence of operations.

All these features, it is claimed, are present in the Dean electric valve-control system, which is constructed by Messrs. The Igranic Electric Company, Limited, Bedford, and is applicable to practically all types and sizes of valves, from 1 in. to 72 in. in diameter, for pressures up to 3,000 lb. per square inch. A characteristic feature of this system is that the limit switch simultaneously performs two functions at the instant the valve is accurately and effectively closed: It disengages the valve from the motor, so that the former stops instantly without jamming; on the other hand, the motor does not stop before the valve is closed. The limit switch also opens the circuit so that the motor will stop when its momentum has been dissipated. Again, when opening, lost motion allows the motor to accelerate to normal speed before it begins to take the load due to the valve. As a result, it is pointed out, a hammer blow is given which unseats the valve without excessive expenditure of power, even if it has become stiff through long closure or from any other cause. It may be added that the operating unit can be automatically de-clutched, so that the valve can be controlled manually and cannot be left in an inoperable position. The whole operating unit is totally enclosed and is practically moisture-proof. Moreover, there are no exposed gears and only one projecting shaft.

Fig. 1.

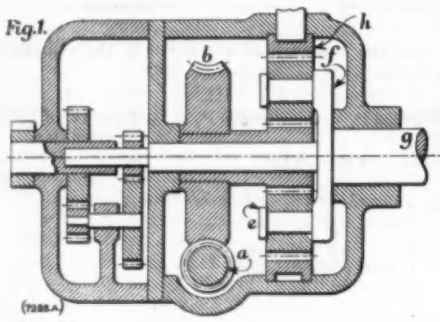
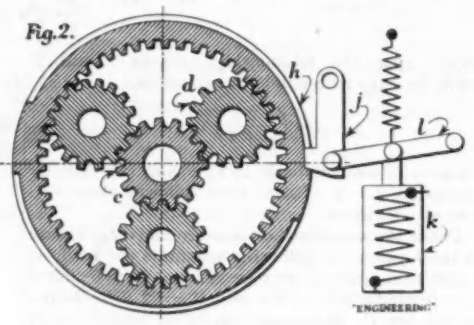


Fig. 2.



Briefly, the valve-operating unit consists of a driving motor, reduction gears, limit-switch mechanism and pawl, all of which are mounted in a single case, as shown diagrammatically in Figs. 1 and 2. Fig. 3 on page 564, illustrates a Dean valve-control installation with a lunar master time switch, to suit the tides, at the Seaton Burn sewage-disposal works. Referring to Figs. 1 and 2, the driving motor shaft is coupled to the worm-shaft *a* by a two-jaw clutch, both the motor and the worm shafts running in ball bearings. The worm-wheel *b* is keyed to a sleeve which forms the sun pinion *c* of a planetary gear. The three planet pinions *d* are mounted on large studs *e*, which are forced into a flange *f*, and this flange forms part of the low-speed driving shaft *g*. The planet pinions mesh with the internal gear *h*, which is the outer member of the planetary gear system. This gear fits into a recess machined in the casing and revolves freely in this recess. The outer surface of the internal gear is provided with a peripheral channel containing two stops. A restraining pawl *j* is moved into the clutch position by the solenoid *k*. This straightens the toggle *l*, which holds the pawl rigidly in place. The limit-switch mechanism comprises two limit switches of the quick-break type, one for the opening and the other for the closing direction. When used with gate valves, these switches are operated by a train of reduction gears, which are driven by the slow-speed shaft *g*. When used with other types of valve, the switches are operated by the tight-seating relay referred to below.

As regards operation, when the motor is started the internal gear revolves until the stop is brought up against the pawl. This arrests the movement of the gear with the suddenness of a hammer blow and compels the flange carrying the three planet pinions to revolve. These pinions, in turn, drive the low-speed shaft, so that the valve is moved in the opening or closing direction, according to the conditions of operation, until the limit of travel is reached. At this point the appropriate limit switch simultaneously opens the solenoid and motor circuits. The opening of the solenoid circuit permits the restraining pawl *j* to be quickly withdrawn by spring action, thus leaving the internal gear and planetary gear system free to revolve. The slow-speed shaft and slow-moving valve parts are consequently no longer driven. They therefore stop immediately without jamming the valve, while the motor rotates with the planetary-gear system until its momentum is absorbed and it comes to rest. On gate valves the limit switch operates when the slow-speed shaft has made a predetermined number of revolutions in the required direction. If the control is properly adjusted, the valve will, therefore, close to exactly the same point, whether the stuffing gland is tight or slack and whether there is pressure on the gate or not. In the case of other types of valve, the limit switch operates directly the torque developed indicates that the valve is tightly seated. Consequently, it is claimed, the valve stops instantly without jamming, but never partially closed.

The alternating- or direct-current motors driving these units are controlled by reversing starters or contactors. A typical example of a control panel, with the cover removed, is illustrated in Fig. 4, page 564. The contactors are fitted with the necessary operating and overload relays, and are, in turn, controlled from push-button stations comprising three buttons, marked "open," "close" and "stop," and having two indicating lamps to show whether the valve is open or closed. If both lamps are lighted at the same time, the valve is in an intermediate position.

The use of high pressures and relatively high temperatures in steam power plants, and in the chemical industry, has imposed unusual requirements for the positive and accurate setting of motor-operated valves. Strains and resultant deformation may be caused by these pressures and by expansion and contraction of the parts due to temperature changes. Under these conditions, the standard motor control with a mechanical limit set for a definite number of turns would not close the valve tightly or, alternatively, might seat the valve before the mechanical limit had been reached, and thus cause damage. To overcome this difficulty, the special tight-seating relay, mentioned above, has been developed. This relay is enclosed in the contactor panel and ensures that the valve is seated at a definite pre-determined pressure or at a fixed motor torque. The mechanical limit switch is set to open while the valve is an appreciable distance from the seat. When the valve begins to seat, therefore, the motor current builds up until it reaches a predetermined value and trips the tight-seating relay. This allows the pawl to be withdrawn and the motor to be disconnected from the supply. This device may also be applied to opening the valve, so as to ensure that it is fully open and thus to keep the pressure off the packing.

Although the Igranic Dean units have been primarily developed for the remote-control of valves as shown in Fig. 3 and in Fig. 6, which illustrates a valve and control unit installed in the Chester waterworks, they can also be used for controlling watertight doors on ships. An example of this application is illustrated in Fig. 5. These doors are controlled from the bridge, but can also be operated locally. Fig. 4 shows the control panels. Another interesting application is the control of high-voltage air-break switches by means of push-buttons in the power house.

PRESSED-STEEL TANKS.—An interesting brochure dealing with large and small tanks, built up from pressed-steel unit plates, has recently been issued by Messrs. Braithwaite and Company, Engineers, Limited, Horseferry House, Westminster, London, S.W.1. Photographs of tanks erected in all parts of the world are reproduced in the brochure and illustrated technical data are included.

AXIAL-FLOW COMPRESSED-AIR DRIVEN FANS.

MESSRS. DAVIDSON AND COMPANY, LIMITED, BELFAST.

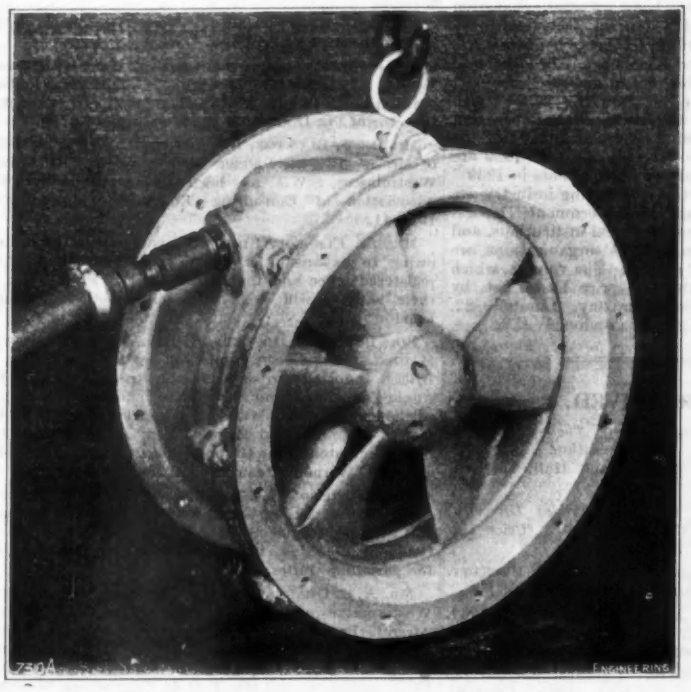


FIG. 1. 16-IN. FAN SHOWING AIR CONNECTION.

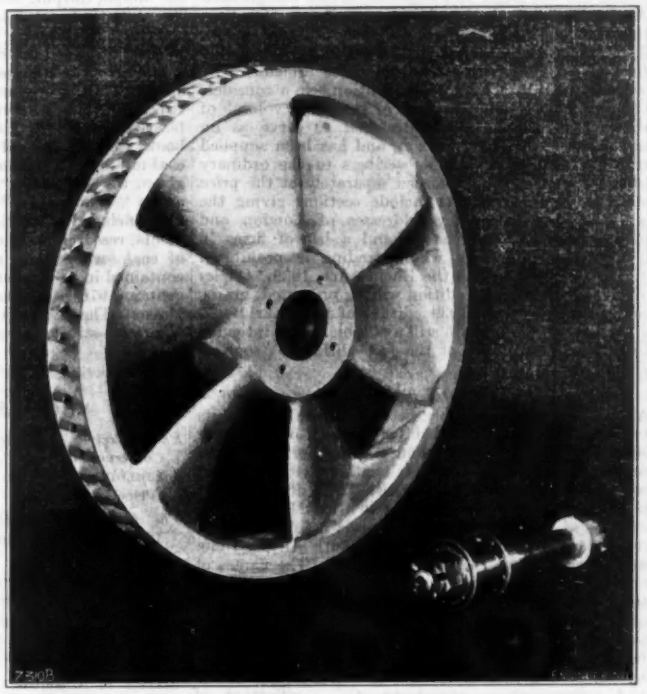


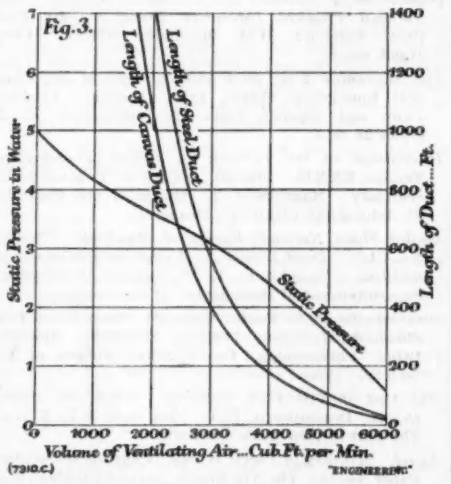
FIG. 2. IMPELLER AND TURBINE OF 16-IN. FAN.

AXIAL-FLOW COMPRESSED-AIR DRIVEN FANS.

THERE are some situations in which, owing to the presence of an explosive atmosphere, a risk may be involved in driving any ventilating fans required by means of electric motors of the usual types. Such situations occur in certain factories in which chemical processes are carried on and in the so-called fiery mines. The latter, of course, have ventilating equipment at the pit head, but generally need auxiliary fans in various parts of the workings. A supply of compressed air is usually available in mines, being provided for driving cutting and conveying machinery, and this supply can be used to drive suitable ventilating fans with perfect safety. Messrs. Davidson and Company, Limited, Belfast, have given attention to this question and have developed the "Sirocco" axial-flow compressed-air driven fan to meet the conditions encountered in the auxiliary ventilation of mines. These fans are manufactured in two sizes, viz., 12 in. and 16 in. in diameter, two views of a fan of the latter size being given in Figs. 1 and 2, while a typical performance curve is reproduced in Fig. 3. One of the prime requirements of a fan for auxiliary mine ventilation is that it should be portable and easily handled, without sacrifice of strength and durability. By the use of a light alloy, the weight of the 12-in. fan has been kept down to 50 lb. and that of the 16-in. fan to 70 lb. Both sizes are provided with an eye for suspension or lifting.

The view, Fig. 1, which is taken looking on the inlet side of the fan, shows that both the inlet and discharge sides are provided with drilled flanges. These permit the fans to be installed either at the inlet end of the duct system or at any intermediate point, as may be required. The duct system may be constructed of either canvas or steel, and in either case adequate auxiliary ventilation is secured with the inserted fan. It will be observed that the inlet of the fan shown in Fig. 1 is bell-mouthed. This construction only applies to the 16-in. fan, but, when the 12-in. fan is attached to the inlet end of the duct, a bell-mouth inlet should be fitted to its casing. A wire guard can be supplied for the inlet. When either fan is inserted in the duct it is desirable to fit the latter with a flared inlet.

Referring again to Fig. 1, it will be observed that the rear part of the casing, in conjunction with the inner part of the rim of the impeller, forms an unobstructed passage, and that the integral support arms in it are streamlined and act as guide vanes to correct the direction of the air flow. The shaft on which the



fan, with its turbine wheel, rotates is fixed in the guide-vane boss. The bearings are housed in the impeller boss and consist of a located ball bearing near the vane boss and a non-located roller bearing near the impeller boss cap, the bearings being spaced by distance pieces abutting on both the inner and outer races. Lubrication of the bearings is effected by means of a Tecalemit nipple for use with a grease gun. The boss cap, being hollow, forms a reservoir of a capacity which renders constant attention unnecessary.

The impeller and shaft are shown in Fig. 2, and it may be mentioned here that the shafts of the 12-in. and 16-in. fans are interchangeable. It will be clear that the turbine wheel and the impeller are integral, the turbine blades being machined out of the solid rim of the impeller. The impeller blades are of aerofoil section and are shaped to give a high efficiency. A special non-corrosive alloy of aluminium is employed, the high strength to weight ratio of which makes it possible for the impeller to run with safety at high speeds. The impeller rim runs in a recessed chamber in the casing, the chamber being formed to take the nozzle at one point, as seen in Fig. 1. The nozzle is of the convergent-divergent type, and is held in place by means of a screwed nipple having a thread on its outer end to take the compressed-air main. The body of the nozzle is screwed internally, so that it can be readily withdrawn by means of a bolt, without damaging it or dismantling other parts of the fan. The nipple must, of course, be withdrawn first, being provided for this purpose with an external hexagon. The exhaust chamber has been designed so as to permit easy escape of the air leaving the turbine, the exhaust stream joining the main air stream without shock, thereby enhancing, by its inductive effect, the efficiency of the fan.

Typical performance curves are given in Fig. 3. This diagram serves for two sets of conditions. Each size of fan is provided with alternative nozzles, so that the fan can readily be adapted to suit the air pressure available. One of these nozzles has a throat diameter of 0·25 in. and is suitable for compressed-air supply pressures up to 80 lb. per square inch. The other nozzle has a throat diameter of 0·295 in. and is suitable for supply pressures up to 60 lb. per square inch. The fan performance with the small nozzle and the higher supply pressure is the same as that when using the larger nozzle and the lower pressure. The curves, Fig. 3, refer to the 16-in. fan. The left-hand scale gives the static discharge pressure in inches of water, while that on the right gives the length of the duct in feet. This length, however, is only approximate, and pre-supposes a flared inlet-end. The volume of ventilating air delivered, in cubic feet per minute, is read on the base of the diagram. It is interesting to note the effect of the smoother surface of a steel duct as compared with a canvas duct of the same length. Thus, with a duct length of 400 ft., the fan will deliver about 3,400 cub. ft. of air per minute, if the duct is of steel, as compared with 3,000 cub. ft. per minute in the case of a canvas duct. With a compressed-air supply at a temperature of 85 deg. F., the free air at 60 deg. F., and the barometer reading 30 in. of mercury, the compressed-air consumption required for the outputs indicated in Fig. 3 is 81 cub. ft. per minute at a pressure of 80 lb. per square inch, and 87 cub. ft. per minute at a pressure of 60 lb. per square inch. Under the same conditions of working, the consumptions of the turbine of the 12-in. fan are 52·8 cub. ft. per minute and 59 cub. ft. per minute, respectively, the nozzles having throat diameters of 0·20 in. for 80-lb. working pressure and 0·24 in. for 60-lb. working pressure. Curves for the performance of the 12-in. fan are not reproduced, but to give some idea of the relative output it may be said that this size, with approximately 400 ft. of steel duct, will deliver about 1,630 cub. ft. of air per minute, as compared with the 3,400 cub. ft. per minute of the 16-in. fan, the static pressure being virtually identical in the two cases at these deliveries.

ANNUALS AND REFERENCE BOOKS.

The Mercantile Year Book and Directory of Exporters.—The many changes of address which the war has caused among mercantile firms have brought special difficulties to the compilers of commercial reference books, and the paper shortage has further complicated the problems of their publication. Messrs. Lindley-Jones and Brother, Limited, 52, Bishopsgate, London, E.C.2, the publishers of *The Mercantile Year Book and Directory of Exporters*, have met these difficulties by producing a "War Emergency Edition," in a considerably condensed form, in place of the usual volume of about 1,000 pages. It is designed to serve as an addendum to the 1939 edition, and has been supplied as such to all registered subscribers to the ordinary edition, but may be purchased separately at the price of 2*s.* 6*d.* The contents include sections giving the temporary or emergency addresses of London and provincial export merchants, and a list of firms in neutral countries with whom trading is prohibited under the Trading with the Enemy Act, 1939. Copies of this supplementary edition will be presented, gratis, to purchasers of the 1939 edition of the Year Book, a few copies of which are still available. It is intended to resume publication of the full editions as soon as circumstances permit.

The Water Engineer's Handbook and Directory, 1940.—As its name implies, this little volume, now in its twelfth edition, is intended for the use of engineers engaged in water-supply undertakings or connected with waterworks practice. It contains a directory of water undertakings in the British Isles, of catchment boards and drainage authorities in Great Britain, and of some of the leading water-supply administrations in Australia, New Zealand, Canada, South Africa, India and other parts of the British Empire. The names of the chief officers of water undertakings are given, together with the source of the supply, the character of the water and its treatment, the water rate, the total capital expenditure, and other data. The handbook section of the volume consists of 80 pages of hydraulic data and formulæ concerning pipes, storage and compensation, aqueducts, the purification of water, prime movers and pumps, and rainfall. Special chapters have been contributed by Dr. J. Glasspoole on "The Rainfall over the British Isles during 1939," and by Mr. H. T. Seymour on "A Review of Case and Statute Law of 1939 as Affecting Water-Supply Undertakings." Lists of water engineers and the authorities with which they are connected and of institutions, Government Departments and associations and societies connected with water and water engineering, are included. The volume is published by Messrs. "Water and Water Engineering," 30–31, Furnival-street, London, E.C.4. The price is 8*s.* 6*d.* net.

The British Engineers' Association Handbook.—The 1940 edition of *The British Engineers' Classified Handbook of Members and their Manufactures*, to give the volume its full title, has recently come to hand. In addition to particulars of the main objects, activities and services of the Association, the book contains an alphabetical list of member firms, their main and branch addresses and agencies throughout the world, a classified list of the manufactures and products of member firms, and a list of British Standard Specifications relating to mechanical engineering. In order to amplify the data given in the directory sections, 170 pages of the volume are devoted to publicity matter issued by the engineering firms concerned. Another useful section is that containing explanatory remarks and suggestions to firms abroad wishing to buy British engineering plant, machinery or accessories. These, we are glad to note, are invited to send their inquiries to the Association written in French, Italian, Spanish, Portuguese, German, Swedish, Norwegian, Russian, or other language. We are informed that 5,500 copies of the handbook have been posted, free of cost, to carefully selected known buyers of engineering products in the home and overseas markets, and we are asked to state that copies will be posted, free of charge, to firms intending to purchase British machinery and accessories if application is made, on their business letter-paper, to the Secretary, The British Engineers' Association, 32, Victoria-street, London, S.W.1.

The Colliery Year Book, 1940.—In spite of difficulties caused by the war, the main features of the eighteenth edition, that for 1940, of *The Colliery Year Book and Coal Trades Directory*, have been brought up to date, with the exception of certain statistics for 1939, which, for obvious reasons, are not available for publication. The directory sections contained in the volume comprise alphabetical lists of colliery owners, individual mines, central rescue stations, coke makers, blast furnaces, gas works, electricity-supply undertakings, coal merchants, coal exporters and shippers, colliery agents, and other organisations and individuals concerned with the winning, processing or marketing of solid fuels. The directory of colliery owners is the longest section in the book, and the information furnished includes the names and addresses of the directors and principal officers of each company, the names and localities of the pits and the nearest railway stations, the numbers of workers employed above and below ground, the seams worked, the classes of coal mined, the annual output, and the types of power employed. The statistical sections of the book are most exhaustive and include data on coal resources, prices, costs of production and distribution, exports, consumption, employment and wages, and accidents and occupational diseases. Other sections deal with the Coal Mines Act, 1911, including Orders up till June 20, 1939; with blasting in collieries; and with periodical literature and books relating to coal mining. Special reviews of the coal-mining industry and of the coal trade in 1939 are given, while a useful "Diary of Chief Events in 1939" and a "Who's Who" in the coal-mining industry are also included. Particulars of Government Departments, research associations, technical institutions, and of coal owners' and mine workers' organisations are contained in an "official" section. The volume, which contains 976 pages, is published, price 1*l.* 1*s.* net, by Messrs. The Louis Cassier Company, Limited, 22, Henrietta-street, Covent Garden, London, W.C.2.

BOOKS RECEIVED.

Photo-Electric and Selenium Cells. Their Operation, Construction and Uses. Second edition. By T. J. FIELDING. London: Chapman and Hall, Limited. [Price 7*s.* 6*d.* net.]

The Colliery Year Book and Coal Trades Directory, 1940. London: Louis Cassier Co., Ltd. [Price 21*s.* net.]

Generation and Transmission. By C. S. BECKETT. London: Blackie and Son, Ltd. [Price 5*s.* net.]

Journal of the Institute of Metals. Volume LXV. 1939. No. 2. Edited by S. C. GUILLAN. London: Offices of the Institute, 4, Grosvenor-gardens, S.W.1.

Society of Chemical Industry. Chemical Engineering Group. Proceedings. Volume XXI. 1939. London: Offices of the Group, 56, Victoria-street, Westminster, S.W.1.

Department of Scientific and Industrial Research. The National Physical Laboratory Report for the Year 1939. London: H.M. Stationery Office. [Price 2*s.* 6*d.* net.]

The Mercantile Year Book and Directory of Exporters. War Emergency edition, 1940. London: Lindley-Jones and Brother, Ltd., 52, Bishopsgate, E.C.2. [Price 2*s.* 6*d.*]

Proceedings of the Institute of British Foundrymen. Volume XXXII. 1938-39. Edited by T. MAKEMSON, Secretary. Manchester, 3: Offices of the Institute, St. John-street Chambers, Deansgate.

United States National Bureau of Standards. Circular No. C425. *Legal Weight per Bushel for Various Commodities.* Compiled by R. W. SMITH. Washington: Superintendent of Documents. [Price 5 cents.]

American Society for Testing Materials. Index to A.S.T.M. Standards, Including Tentative Standards. January, 1940. Philadelphia, Pa., U.S.A.: Offices of the Society. [Free.]

The Port of New York Authority. Nineteenth Annual Report. December 31, 1939. New York, N.Y., U.S.A.: The Port of New York Authority.

Egypt. Ministry of Public Works. Physical Department. Paper No. 38. *The Nile Basin.* Second Supplement to Volume II. *Measured Discharges of the Nile and Its Tributaries in the Period* 1933-1937. By DR. H. E. HURST and the late DR. P. PHILLIPS. Bûlâq, Cairo: Publications Office, Government Press. [Price P.T.50, or 10*s.*]

Egypt. Ministry of Public Works. Physical Department. Meteorological Report for the Year 1934. Bûlâq, Cairo: Publications Office, Government Press. [Price P.T.40.]

Construction Estimates and Costs. By PROFESSOR H. E. PULVER. London: McGraw-Hill Publishing Co., Ltd. [Price 33*s.*]

FORGERY-PROOF WORKS PASS.—The need for preventing unauthorised persons entering premises in which work of national importance is being carried on is nowadays imperative, but identification passes may sometimes be tampered with. A pass which cannot be so dealt with has been produced by Messrs. Miles and Kaye, Limited, 54, Cheapside, London, E.C.4. A photograph of the holder is printed on the pass, along with his name, clock number, department, and National Registration number, and the firm's name and address. The whole is sealed in a transparent case about the size of the ordinary railway season ticket. It will be clear that as the photograph and the pass are printed together, no substitution is possible without the fact being noticeable.

PERSONAL.

MR. R. LAWSON, chief engineer of the Postmaster-General's Department, Australia, has been appointed a member of the Air Board and will act as Director-General of Production and Supply. He has also been appointed to the recently instituted Aircraft Production Commission.

MR. C. C. REID has been re-elected President of the Mining Institute of Scotland.

MR. N. L. GOODCHILD, manager, Pig-Iron Department, Messrs. The Stanton Ironworks Company, Limited, Stanton-by-Dale, near Nottingham, has been appointed Director of Pig Iron under the Iron and Steel Control.

MR. E. J. BUCKTON, B.Sc., M.Inst.C.E., M.I.Mech.E., of Messrs. Rendel, Palmer & Tritton, 55, Broadway, Westminster, S.W.1, has been elected chairman of the Association of Consulting Engineers for the year 1940–41.

MESSRS. CLENSOL, LIMITED have found it necessary, owing to expansion of business, to incorporate their registered office and their laboratories. From June 21 their address will be 6, Glasshill-street, Southwark, London, S.E.1.

SIR BERNARD DOCKER, K.B.E., and MR. JOSEPH MAUDSLAY have been nominated by the Federation of British Industries to serve on the British Group of the Anglo-Egyptian Joint Committee, formed to secure permanent contact between commercial interests in the United Kingdom and Egypt. MR. L. V. MURRAY has been nominated to the Group by the Chamber of Shipping and the Liverpool Steam Ship Owners' Association.

The Minister of Transport has, with the concurrence of the Board of Trade, appointed SIR LEONARD PEARCE, C.B.E., the Engineer-in-Chief of the London Power Company, Limited, to be an Electricity Commissioner for part-time duties.

MR. A. S. QUARTERMAINE, chief engineer of the Great Western Railway, has been appointed by the Minister of Aircraft Production to be Director-General of Aircraft Production Factories. The Minister has also appointed SIR FRANK E. SMITH, F.R.S., to control telecommunications equipment, and MR. T. C. L. WESTBROOK to control aircraft purchases from Canada and the United States.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Electrical Equipment, comprising high-speed circuit breakers, isolating links, insulators, and battery-charging equipment. South African Railways and Harbours, Johannesburg; July 17. (T. 19,785/40.)

Distribution Transformers, 100-kVA, six; 150 kVA, twelve; 200 kVA, thirty; and 250 kVA, 300 kVA, and 400 kVA, 24 of each. City Council, Johannesburg, July 10. (T. 19,831/40.)

Telephone Equipment, comprising private automatic branch-exchange line-finder equipment. Posts and Telegraphs Department, Melbourne; June 18. (T. 19,215/40.)

Motor-Omnibus Chassis, Diesel-engined, complete with 39-40 passenger body. Town Council of Benoni, South Africa; June 24. (T. 19,791/40.)

Kilowatt-Hour Meters, general-service, polyphase a.-c., of various types. State Electricity Commission of Victoria, Melbourne; June 25. (T. 19,859/40.)

Cable, trunk-type. Posts and Telegraphs Department, Melbourne; July 4. (T. 19,216/40.)

Electrical Distribution Material, including insulating tape, insulators, fuses, switchgear, and transformers. Electricity Department, Salisbury, Southern Rhodesia; July 15. (T. 19,595/40.)

Watt-Hour Meters, house-service type, 3,100, a.-c., single-phase, two-wire 200/220-volts, 50-cycles, and 312 polyphase 3-element, four-wire, 380/220-volts, 50-cycles. City Council, Johannesburg; June 12. (T. 19,797/40.)

Sanitary Fittings, earthenware and cast-iron pipes and fittings. Municipality of East London, South Africa; July 10. (T. 19,887/40.)

Stoneware Pipes, 167,000 m., ranging from 102 mm. to 203 mm. in diameter. Argentine National Sanitation Works Department, Buenos Aires; July 15. (T. 19,987/40.)

Oil-Immersed Circuit Breakers, ten 250-MVA and fourteen 150-MVA, triple-pole, for use on a 6,600-volt, 50-cycle system. City Council, Johannesburg; July 10. (T. 20,003/40.)

Distribution Fuse Units, box-type, sixty, 300-amp., and ten 100-amp. City Council, Johannesburg; July 10. (T. 20,005/40.)

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The production of Welsh steam coals continued to be fully taken up last week and consequently a strong tone ruled for all descriptions. Trade to France was briskly maintained and operators generally had sufficient business on their books from this market to absorb the whole of available supplies for some time to come. Furthermore, it was expected that the demand from this market would increase. Consequently the amount of business that could be arranged in other overseas markets was small. It was reported that the sale of a few cargoes for South America had been permitted, and a small quantity was also allocated to Spain. It was announced that a plan for increasing outputs in the South Wales coalfield has now reached its final stages, and it is understood that, after final approval by the National Coal Production Council, steps will be taken quickly to put the proposals into operation. It was officially stated that the plan does not include any proposal for lengthening working hours. All large coals continued to be readily taken up and remained well placed with regard to forward business. Smalls were well engaged and again moved off steadily. The sized sorts were scarce, while duffs were almost entirely disposed of over some months.

The Iron and Steel Trade.—Activity in the iron and steel and allied trades continued on a high level. Manufacturers were very favourably placed with orders and a steady volume of business was offering.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Every effort is being made to increase the production of steel and other materials in this district. As has been the case for some time, the raw and semi-finished steel-producing trades are operating at exceptionally high pressure, large batteries of furnaces working continuously and producing record tonnages. In the heavy machinery and engineering branches activity has been maintained at a high level. Commercial requirements for machinery and engineering products generally are on the increase, and some valuable orders have come to hand during the past few weeks; many of these are on export account. Makers of railway rolling stock report that the recent improvement in demand has been maintained; there is a fairly brisk call for wheels, axles, springs, tyres, and buffers. India and South Africa are reported to be the best of the overseas customers. The demand for steelworks and engineering works equipment has received some impetus during the past few weeks, with the result that producing concerns have an accumulation of orders. Among the lines in demand are rolling mills, forging plants, hydraulic presses, bending machines, lathes, and similar plant. Business is also brisk in electrical equipment. Producers of high-efficiency steels, including stainless, and heat- and acid-resisting materials, are actively engaged in coping with rising requirements. There is an active demand for manganese steel and all types of tool steels. The tool-making branches are producing record outputs, and inquiries show that little difficulty is being experienced in obtaining sufficient supplies of materials. Farm and garden tools are progressive lines.

South Yorkshire Coal Trade.—Outputs at many pits have increased during the past few weeks. The consumption of industrial coal reaches record dimensions, steam coal being in strong demand. Electricity and gas-producing concerns are absorbing heavier tonnages of smalls and slacks. The house coal market is steady. Cokes of all types are in good demand.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The Council of the Institution of Automobile Engineers has decided to cancel the arrangements which had been made for the Institution luncheon, which was to have been held at Grosvenor House, London, W.1, on June 21.

ASSISTANCE WITH PROBLEMS CONCERNING TIN.—The International Tin Research and Development Council, Fraser-road, Greenford, Middlesex, have requested us to state that the experience which they have accumulated, particularly since the war began, on a wide range of processes in which tin is directly or indirectly concerned, is available to engineering firms, free of charge. These processes include grease-tinning and hot-tinning, soldering, and electro-tinning, and the manufacture and use of bearings and bearing materials, bronze, and fusible alloys, particularly for rapid die and punch mounting, tube bending, etc. Advice can sometimes be given by correspondence, but as in many cases personal contact is much more effective, the Council is prepared to send members of its staff to give assistance and advice at firms' works.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Market conditions show little change, but an outstanding feature of the present situation is a further increase of demand for steel. Ordinary customers are seeking to place orders for general industrial needs, but distribution is now under strict control.

Cleveland Iron Trade.—The demand for foundry iron is expanding, but users are receiving adequate supplies. There is little Cleveland pig obtainable, the make still being light and intermittent, but Midland brands are being received on a scale that meets current needs. Secondhands have control of only very moderate parcels of local iron. The fixed prices of Cleveland pig remain on the basis of No. 3 quality at 111*s.*, delivered within the Tees-side zone.

Hematite.—Producers of East Coast hematite are continuing to supply the actual requirements for consumption, though they have but little iron stored. The heavy output is taken up as it becomes distributable, and new orders are difficult to place. As in the Cleveland pig branch of trade, merchants are handling little tonnage. The makers' contract obligations are extensive, and their own consuming works are absorbing large and increasing quantities of iron. A movement towards increasing production is proceeding. The stabilised quotations remain at the level of No. 1 grade of hematite at 127*s.* 6*d.*, delivered to North of England buyers.

Basic Iron.—Basic iron makers are concentrating on providing for the requirements of their adjacent steel-producing plants. As there is still no saleable tonnage, the recognised market value of basic iron remains nominal at 104*s.* 6*d.*

Foreign Ore.—Foreign-ore consumers are in a satisfactory position regarding supplies, imports being regular and adequate.

Blast-Furnace Coke.—A rise in values of Durham blast-furnace coke is not unexpected, notwithstanding the plentiful supply. Business is quiet. Sellers have good order books and are not disposed to add to their extensive commitments, while local users are well covered. Market quotations are ruled by good medium qualities at 31*s.* 8*d.* at the ovens.

Manufactured Iron and Steel.—Semi-finished iron supply is satisfactory and delivery of steel semies is better than had been expected. The output of finished-iron commodities continues to increase, and producers of finished steel are operating their plant at full capacity in order to meet the heavy delivery demands.

Scrap.—Steel scrap is still scarce, but foundry iron scrap is in fairly good supply.

THE INSTITUTE OF BRITISH FOUNDRYMEN.—We are informed that the annual conference of the Institute of British Foundrymen, which was to have been held at Cheltenham to-day and to-morrow, June 7 and 8, and particulars of which appeared on page 543, *ante*, has been cancelled. Written discussion on the papers which were to have been presented, however, is invited, and should be sent to the assistant secretary of the Institute, St. John-street Chambers, Deansgate, Manchester, 3.

BUNNERONG POWER STATION, SYDNEY, N.S.W.—Mr. R. Vine Hall, general manager of the Sydney County Council Electricity Undertaking, New South Wales, informs us that tenders are shortly to be invited for a third 50,000-kW steam-turbine-driven alternating-current generating set for the Bunnerong Power Station. This is required to be in commission by May 1, 1943. Specifications are to be issued in Sydney, but a copy will be available at the offices of Messrs. Preece, Cardew and Rider, consulting engineers, 8-10, Queen Anne's Gate, Westminster, London, S.W.1. The closing date for the receipt of tenders will be October 24, 1940.

HUNTING-KNIFE BLANK.—An interesting method of drawing attention to the operating capacity of their machines is furnished by the distribution of blanks for hunting knife blades by Messrs. Continental Machines, Incorporated, 1301, Washington-avenue South, Minneapolis, Minnesota, U.S.A. These blanks comprise both blade and tang, and are stamped from special spring steel. Full directions for hardening, grinding, and fitting various kinds of handle accompany the blank, which, we understand, can be obtained gratis by firms interested on application to the company named above. The blanks were stamped in a die sawn out by the "Doall" contour machine. When large quantities of similar articles are required, the die, die shoe, punch, stripper plate and automatic stop can, it is stated, be sawn and filed on this machine in five hours only, that is, in considerably less time than is needed by ordinary die-making methods.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

PHYSICAL SOCIETY.—To-night, The Imperial College, Imperial Institute-road, South Kensington, S.W.7. 5 p.m., Extraordinary General Meeting. Revision of Articles of Association. 5.15 p.m., Annual General Meeting. (i) Annual Report of the Council. (ii) Election of Officers.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In answer to the call for a larger supply of munitions, the Scottish steel trade is responding well and production is being speeded up in all directions. Although recent outputs have been exceptionally large, endeavours are being made to increase the tonnage still further, and this will be accomplished with the seven-day working week, now general. No trouble has been reported with regard to supplies of raw materials, and collections of scrap have been very satisfactory. Both heavy and light material are in great demand and the black steel-sheet makers are extremely busy on work of national importance. The following are the current quotations:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, ¼ in. thick, weighing 6 lb. or more per square foot, 14*l.* per ton, and weighing under 6 lb. but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge, in 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—Conditions in the malleable-iron trade of the West of Scotland have not changed during the week and the orders on hand are being carried out as rapidly as possible. The re-rollers of steel bars are still working at full capacity to meet the demands of their clients, who are pressing for deliveries against contracts. Fairly good supplies of raw materials are available, and, moreover the tonnage of semies coming in has been very satisfactory. Prices are steady and are as follows:—Crown bars, 14*l.* 2*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; and re-rolled steel bars (tested), in 4-ton lots, 14*l.* 3*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade the output from the furnaces in blast is well maintained, and the iron-masters are doing their utmost to keep all their customers supplied. This is naturally difficult, as production generally, and especially in the steel trade, is increasing rapidly. The demand for foundry grades is better and has a tendency to improve further. The following are the current market quotations:—Hematite, 6*l.* 7*s.* 6*d.* per ton, and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 5*l.* 15*s.* per ton, and No. 3, 5*l.* 12*s.* 6*d.* per ton, both on trucks at makers' yards.

IRON, STEEL AND METAL-WORKS EQUIPMENT EXPORT GROUP.—The manufacturers of rolling-mill, hydraulic and blast-furnace plant and auxiliary machinery have established an Export Group, termed the Iron, Steel and Metal-Works Equipment Export Group. Membership of the Group is open to all manufacturers of hydraulic pumps exceeding a pressure of 500 lb. per square inch and working on an enclosed circuit. The chairman of the Group is Mr. W. Kilpatrick, of Messrs. Davy and United Engineering Company, Limited, Sheffield, and manufacturers wishing to become members should write to the secretaries, Messrs. Peat, Marwick, Mitchell and Company, 94-98, Petty France, Westminster, London, S.W.1.

THE INSTITUTION OF SANITARY ENGINEERS.—The first sessional meeting of the Institution of Sanitary Engineers, since the outbreak of the war, was held at Caxton Hall, Westminster, on May 31. In opening the proceedings, Mr. C. B. Jackson, the Chairman of the Council, stated that an emergency committee, appointed when war was declared, had had several meetings and had decided to recommence the Institution's normal sessional activities as far as possible. The first meeting in the forthcoming autumn session would be held at 6 p.m., on September 27, when Lieut.-Col. E. F. W. Mackenzie, O.B.E., M.C., Director of Water Examination, Metropolitan Water Board, would given an address on "Water Sterilisation, the Choice of Methods." After a brief talk, chiefly of a reminiscent character, given by Mr. A. Sciver, B.Sc., F.I.C., the President of the Institution, Mr. David M. Watson, B.Sc., M.Inst.C.E., presented the Institution's Bronze Medal to Mr. G. Bernard Godfrey, who had obtained the highest percentage of marks in the associate-membership examination held in 1939.

THE DEAN ELECTRIC CONTROL SYSTEM FOR VALVES.

MESSRS. IGRANIC ELECTRIC COMPANY, LIMITED, BEDFORD.

(*For Description, see Page 560*).

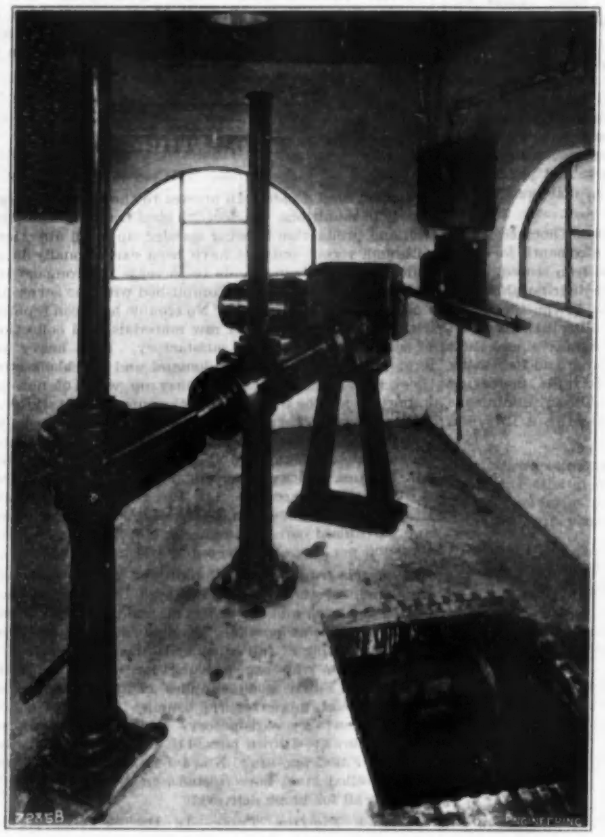


FIG. 3. CONTROL UNIT WITH LUNAR TIME SWITCH.

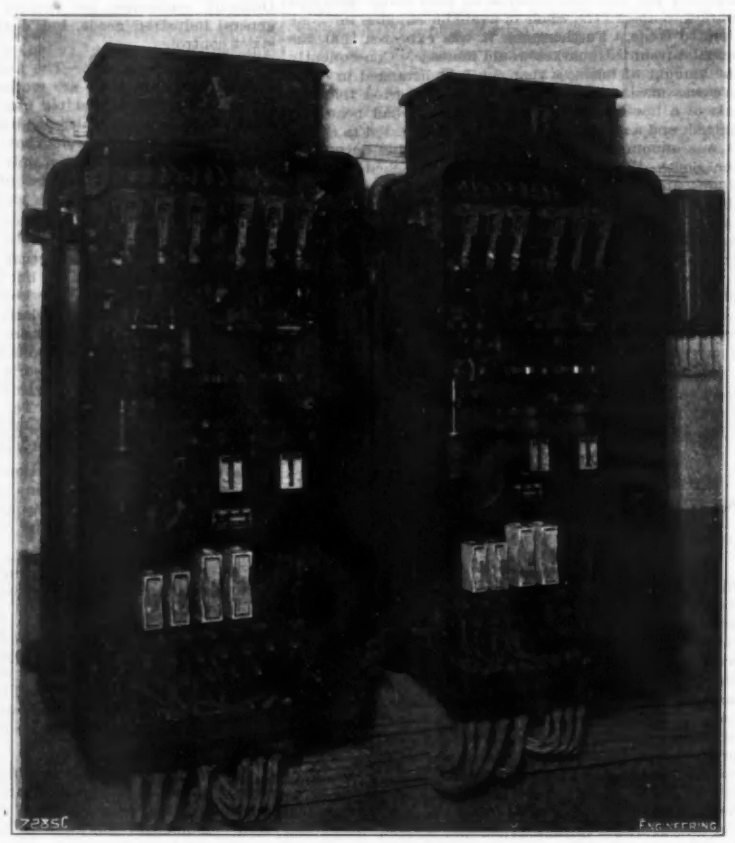


FIG. 4. CONTROL PANELS FOR WATERTIGHT DOORS.

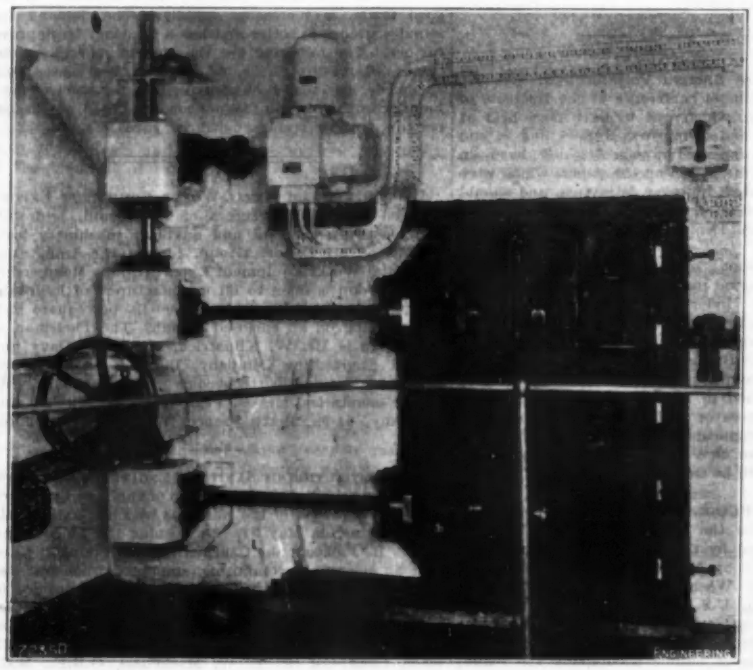


FIG. 5. WATERTIGHT-DOOR OPERATING GEAR.

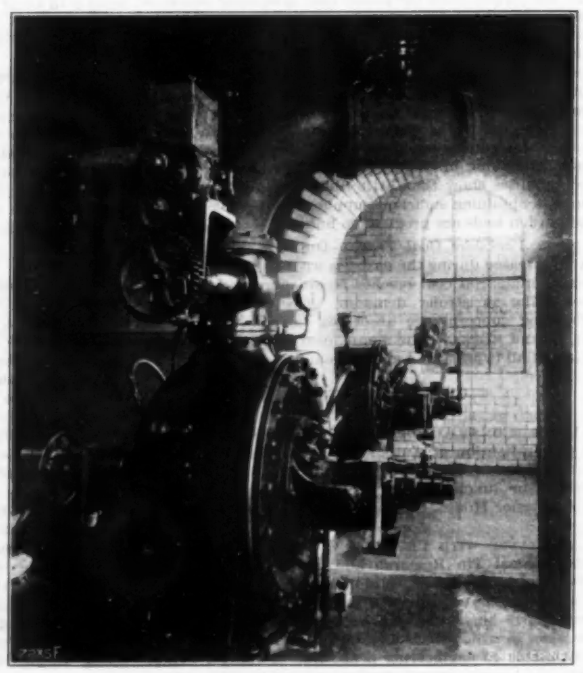


FIG. 6. VALVE UNIT IN WATERWORKS.

ITALIAN SHIPBUILDING AND ARMAMENTS CONSTRUCTION.—We have received from the group of Italian shipbuilding and armament firms now known as Odero-Terni-Orlando a very fully illustrated volume describing the resources of its component firms. The group consists of the former Odero, Fiat-San Giorgio and Orlando shipyards, situated at Genoa, Spezia and Leghorn, respectively; the former Vickers-Terni armament works at Spezia; and the ship-repairing establishment of the Odero firm at Genoa. Some interesting illustrations show the development of naval and mercantile shipbuilding in Italy and are supplemented by historical notes relating to the several shipyards and works. A point that is well brought out is the part played by these Italian firms in supplying the requirements of foreign navies.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, JUNE 7, 1940.

VOL. 149. No. 3882.

THE MUNITIONS DRIVE.

THE reconstituted Government has now been in office long enough for most of the Ministers and heads of Departments to grasp the immediate requirements of their new positions, and the effects of the more urgent drive for increased munitions production, inspired by events in Belgium, are already apparent. The response to the appeal for "work at war speed," made by Mr. Herbert Morrison, M.P., the Minister of Supply, has been stated by Mr. Morrison to be a "very marked" increase in the rate of output of essential munitions. How unprecedented is the situation that has called forth this effort was clearly indicated by the Prime Minister, in his speech to the House of Commons on June 4. The British Expeditionary Force, which found itself trapped in Belgium, had been equipped with a completeness and an attention to detail that was unique in British military history. Practically the whole of that elaborate equipment, including nearly 1,000 guns and an immense fleet of mechanical transport, had to be sacrificed to the major necessity of evacuating the men themselves. Even if the process of re-equipment consisted only of issuing fresh material from store to replace that lost in Flanders, the Force could not be reassembled and transported again to the Continent in a mere week or two; and there is every indication that the demand for armaments of all kinds in the near future will be heavy indeed.

The realisation of this fact, and of the scale of German equipment in the air and on the ground, has resulted in various significant steps to expand and accelerate production in two important directions. On May 27 it was announced that Lord Beaverbrook, Minister of Aircraft Production, had appointed an emergency committee with full authority to deal with the production of aircraft equipment; and, two days later, the Minister of Supply stated in the House of Commons that he had set up a Tank Board to consider the whole problem of the design and production of tanks, and to advise him on the action required. The Parliamentary correspondent of *The Times*, commenting on the latter appointment, described the object of the Tank Board to be that of devising measures to bring about the mass production of tanks "of a formidable type," in the light of experience gained on the battlefields.

The committee on aircraft equipment consists of three members, Mr. C. J. Stewart, since 1938 Director of Civil Research and Production at the Air Ministry, being chairman. The other members are Sir Allan Gordon Smith, managing director of Messrs. S. Smith and Sons (Motor Accessories), Limited, and Mr. F. J. E. Brake, a director of the International Marine Radio Company, Limited. At the time of writing, the full personnel of the Tank Board has not been announced, as the representatives of the War Office and the Ministry of Supply have still to be appointed. The appointments so far made comprise Sir Alexander Roger, chairman of Messrs. British Insulated Cables, Limited, who will be chairman of the Board; Mr. A. A. M. Durrant, a chief engineer under the London Passenger Transport Board; Mr. A. J. S. Moyses, managing director of the Birmingham Railway Carriage and Wagon Company, Limited; and Mr. G. W. Thomson, of the Association of Engineering and Shipbuilding Draughtsmen and a member of the General Council of the Trades Union Congress.

Among the other steps taken to accelerate the national production of arms is the census, now in process of compilation, of the actual hours of operation of all machine tools in the engineering and allied industries in Great Britain and Northern Ireland. The scope of the inquiry extends to all works engaged in engineering, iron founding, boiler making, motor-vehicle and aircraft construction, metal working, instrument making and shipbuilding. The forms were distributed last week, and the records were to commence at midnight on Saturday, June 1, and to be continued throughout one week. In view of the possibilities of ill-informed interference by temporary officials, which such an investigation might portend, it is satisfactory to have the assurance of the Minister of Supply that, in exercising the powers of control conferred upon him by the new Emergency Powers Act, he would avoid such interference as far as possible, and would impose the minimum of instruction upon factories and works which showed, by their results, that they were efficiently conducted and were being operated "with determination and public spirit." In present circumstances, the latter requirement may be taken as assured. Efficient conduct, however, involves more than merely the skill and consistent endeavour of those actually engaged in operating a particular works. It depends to a very great extent upon the work of officials in the various departments, who now control the placing of orders and the supply of the materials, without which work cannot be begun; and, in this respect, there are still disquieting stories of local triumphs of red tape over common sense, of work held up because of too strict adherence to needlessly detailed and rigid specifications, and of failure to differentiate between the essential and the merely desirable. Quality is important, but experience has shown that quantity is not less essential in view of the greatly quickened tempo of modern warfare. This is no time for elaborate drawings of minor details which are, at best, no more than means to an end that could well be achieved by more direct, if less polished, methods.

The question of the most efficient employment of the country's available labour force, obviously, is bound up to a certain extent with the results of the census of machine-tool utilisation, now proceeding. As Sir Alfred Herbert, in particular, has insistently pointed out, there is no reason why machines should not be worked continuously by relays of operators. At the present time, the desired increase of production is being achieved by working longer hours with the existing personnel, but there are limits to the continuous output that can be maintained in this way. Some extension of the hours normally worked by the individual is not impracticable, for it must be remembered that, prior to the last war, a working week of 53 hours or 54 hours was customary in many industries and was regularly borne without

complaint. Even longer hours were frequently worked for short periods, and without the urge of an emergency such as the present, when the importance of a contract required a special effort.

Careful study has established, however, that a long-continued overload does not produce the best results, either in quality or quantity of output, even though the individuals concerned may voluntarily undertake it; and a proper organisation of factory personnel, to enable adequate rest to be assured, is one of the first problems that will arise when the present efforts to divert a larger proportion of the available labour to direct war production reach their climax. Such an organisation does not necessarily mean a resumption of normal holidays, however widely staggered; and, indeed, it is likely that there will be a general reluctance to be absent from work for any extended period, on the part of those who have relatives in the fighting services. The necessary relaxation will have to be achieved, in the main, by a proper arrangement of shifts, which should be so devised as to ensure a regular transfer from day work to night work, with appropriate short breaks at suitable intervals. Hitherto, schemes for continuous operation of machines have been usually based on a system of either two or three shifts, of approximately equal duration; but there is no reason why this should not be modified, not only in works where the nature of the operations imposes a fluctuating load, but also in those having a sensibly uniform rate of output.

One such system, which has been brought to our notice by a retired naval officer, aims at securing a complete continuity of operation by means of four shifts, three working on the basis of six hours "on" and twelve hours "off," while the fourth rests for approximately two and a half days. There are 28 six-hour periods in a whole (seven-day) week, and these, if spread over four shifts in the manner indicated, would give each shift seven turns at work and a 42-hour working week; while the plant would be kept in 100-per cent. continuous operation without even the breaks now occasioned by meal hours. War does not stop for meals, and, by arranging a tea-and-sandwich service at about half-shift, the machine operators need not leave their posts. We are well aware that this proposal directly contravenes the intent and requirement of recent factory legislation, which ordains that employees shall not eat in the workshop; but generations of workpeople have done so and have taken no harm by the practice. When the future of civilisation is at stake, not even the cherished tenets of social-welfare enthusiasts can be regarded as sacrosanct. Mr. Morrison has declared his intention to act in "the spirit of absolute determination that no personal or material vested interests and no past habits of thought" shall be allowed to stand in the way of the drive for victory.

Without going too closely into the details of a scheme which would probably require considerable preliminary staff work to plan in its entirety, it may be pointed out that a material aid towards complete continuity of operation would be afforded if the shifts can be arranged to overlap by ten minutes, so that the work may be taken over properly. With simultaneous in and out booking, there is a loss of at least ten minutes. The men who are finishing are apt to stop work in order to collect their personal belongings, put on their coats, etc., and the incoming shift may be expected to spend a few minutes in picking up the state of the job in hand. In the aggregate, this hiatus amounts to an appreciable loss of useful working time.

The principal objection that might be urged against the proposal for a four-shift system is the possible difficulty of finding sufficient additional personnel to put it into practice; but this is a difficulty which should not prove insuperable when the Ministry of Labour and National Service has completed the investigation into the present extent of employment in non-essential activities. The response to Lord Beaverbrook's appeal for garage mechanics was immediate, and must have resulted in a considerable accession of valuable skilled labour; and the inquiry now proceeding among local authorities, with a view to releasing men for munitions work, should bring a further useful body of men into the armament industries.

MICROPHOTOGRAPHS AND PHOTOMICROGRAPHS.

CONSIDERABLE work is now being done, particularly in the United States, in the photographic reproduction of documents to a very small scale on cinema film. The reproductions are primarily intended for the use of those who cannot obtain access to the originals. No pretence is made, we imagine, even by the most enthusiastic exponents of the process, that these small-scale copies, which have to be read with some type of magnifying apparatus, are as convenient as full-sized photographic copies, but the compensating advantages outweigh any inconvenience in use. The small-scale copies are much cheaper, the postage rates on them are smaller, and bulk is so reduced that problems of storage are simplified. We dealt with this subject in a general way in our issue of October 15, 1937,* and need not here repeat the description then given, but to those who are not familiar with the procedure, a brief reference to the activities of the Engineering Societies' Library of New York in this field may be informative.

The Engineering Societies' Library, which is the joint library of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, has long made a practice of supplying Photostat prints to its members, from the 160,000 volumes and thousands of periodicals in the collection. The cost of this service, including postage to any part of the world, is 30 cents for each negative print, 11 in. by 14 in. If positive prints are required, the cost is 30 cents extra. Depending on the size of the original, the Photostat prints cover one or two pages. Reduced-scale copies on 35-mm. film have now been introduced, at a charge of 4 cents per exposure, this usually covering one page. This service is subject to a minimum charge of 1·25 dols. per volume copied, but it is clear that, if any user requires more than one or two pages from a technical journal, the film copies will show a very substantial reduction in the charge made.

The Engineering Societies' Library calls these reduced-scale copies "microfilms." There has been a tendency in this country to call them "microphotographs," and we used that term (not, however, without protest) in the article previously mentioned. Dr. Leonard Sayce, of King's College, Newcastle-upon-Tyne, who has done much work in this field, prepared a paper for the meeting of the Association of Special Libraries and Information Bureaux, which was to have taken place in Nottingham last September. It appears in the printed proceedings of the Association, under the title "Microphotography in 1939," and was presented at a special meeting of A.S.L.I.B., held at the Science Museum on April 12. The paper points out that microphotography is by no means new, as, in 1858, Benjamin Dancer, a Manchester optician, using a modification of the wet collodion process, made reproductions of religious and other pictures on areas little larger than a pin's head. These were mounted in microscope slides and were intended to be viewed through an ordinary microscope. Clearly, these reproductions were neither of scientific nor industrial value, and belonged to the type of scientific toy which was popular in their time. They were followed, in 1870, by something more useful, when Dagron produced very small-scale photographic reproductions of documents in order to enable dispatches to be sent into the beleaguered city of Paris by pigeon post.

It seems a reasonable assumption that the use of the term "microphotograph" dates from these early activities, which concerned the reproduction of large objects on a small scale. This also applies to the work now being done in the copying of documents. When, however, metallurgists and biologists use the word, they mean the exact opposite—the reproduction of small objects to a large scale. This confusion in terminology is added to when both these classes of scientific worker employ the term "photomicrograph" as an alternative to "microphotograph," the two words being treated as having a similar meaning. On the whole, "photomicrograph" is probably being favoured, but none the less, the term "microphotograph" is in common use to indicate a photographic enlargement showing the structure of a metal or a biological specimen. Of late years, the Iron and Steel Institute appears to have settled down to yet another form—"micrograph"—but whether this is to be taken as a contraction of photomicrograph or microphotograph we do not know. Of the two forms, microphotograph would appear to be preferable, especially for metallurgical work, owing to its affinity to the much-used word, microstructure.

Admittedly, these remarks run counter to the authority of the Oxford Dictionary, which states that a microphotograph is "a photograph reduced to microscopic size." The date for this usage is given as 1858, so that it may be assumed to be derived from the activities of Benjamin Dancer. A photomicrograph is defined as "a photograph of a microscopic object on a magnified scale." These are, no doubt, the derivative meanings of the words. There is nothing unusual, however, in a word changing its connotation in the English language, and in present-day usage in scientific work an enlargement of a very small object is commonly referred to as a microphotograph. This form, as compared with photomicrograph has the important advantage of closely resembling the French *microphotographie* and the Swiss *mikrofotogramm*.

In view of this state of affairs, it is desirable that confusion should not be made worse by the employment of the word "microphotograph" in documentation work. This usage may have historical justification, but the extensive use of the word, in an opposite sense, in scientific circles, over a period which must now be approaching fifty years, makes it impossible to maintain that librarians have any claim on a word which, until recent years, they had abandoned since the siege of Paris. The undesirability of employing the word in connection with documentation is recognised, we believe, by Dr. Sayce, and in the early part of this paper he twice uses the word "microcopying." It would be a general convenience if the term "microcopy," derived from this, could be generally adopted for small-scale reproduction of documents. It is a distinct improvement on "microfilm," which seems to be coming into use in the United States. Although these records are being made on cinema film, there is no essential reason why they should be, and it is undesirable to adopt a name which, sooner or later, may become descriptively inaccurate.

* ENGINEERING, vol. 144, page 432.

NOTES.

THE INSTITUTION OF CIVIL ENGINEERS.

Two notable awards were made at the meeting of the Institution of Civil Engineers, held on Tuesday, May 28. The James Alfred Ewing Medal, founded in 1936 in memory of the late Sir J. A. Ewing, F.R.S., and awarded annually "for specially meritorious contributions to the science of engineering in the field of research," was presented to Professor Geoffrey Ingram Taylor, Fellow and Yarrow Research Professor of the Royal Society; and the Sir Charles Parsons Memorial Medal, founded in the same year as part of the Sir Charles Parsons Memorial, was presented to Dr. Henry Lewis Guy, F.R.S., M.Inst.C.E., to commemorate the Memorial Lecture on "Some Researches on Steam Turbine Nozzle Efficiency," which he was to have delivered at the Institution, but the actual reading of which was cancelled owing to war conditions. The lecture was printed in ENGINEERING of December 22 and 29, 1939. The first award of the Ewing Medal was made in 1937, to Mr. C. S. Franklin, and the second, in 1938, to Professor A. H. Gibson, D.Sc. The recipient for 1939, Professor G. I. Taylor, has made many contributions of distinction to various branches of mathematical physics, more especially in the fields of meteorology, aeronautics, and the plastic deformation of solids. He has done particularly valuable work in investigating the torsional stiffness of airscrew blades. The Sir Charles Parsons Memorial, founded in accordance with the report of an executive committee of the Royal Society, is of a three-fold

character, consisting of a memorial to be erected in Westminster Abbey, a Parsons Memorial Library, and an annual Lecture, on any of the numerous subjects in which Sir Charles Parsons was interested, and the commemorative medal. The lecturers are nominated in turn by the Royal Society, the Institutions of Electrical, Mechanical and Civil Engineers, the Institution of Naval Architects, the Institute of Marine Engineers, the Physical Society, and (in every fourth year), the North-East Coast Institution of Engineers and Shipbuilders. It is provided that, in the last-named instance, the lecture shall be delivered on the North-East Coast. Dr. H. L. Guy, the 1939 lecturer, has been chief engineer since 1919 of the mechanical department of Messrs. Metropolitan-Vickers Electrical Company, Limited, and is a vice-president of the Institution of Mechanical Engineers.

The Powers of the Electricity Commissioners.

Extended comment on the action of the King *versus* the Electricity Commissioners *ex parte* the Chester Corporation, judgment on which was delivered in a Divisional Court of the King's Bench on Wednesday, May 22, is not practicable, as an appeal is not outside the bounds of possibility. As the matter raised is one of considerable interest, however, the facts may be briefly stated. Some time ago, the Corporation applied for permission to extend their generating station at Queensferry, on the ground that this would save some 91,000*l.* per annum, compared with the alternative of drawing supplies from the Grid. The Central Electricity Board, on the other hand, contended that such an extension would not fit in with their scheme for the area. After a public inquiry, the Commissioners upheld this view, though they agreed that the Corporation's scheme was financially the more attractive. In so doing, they took advantage of Section 18 of the Electricity (Supply) Act of 1926, which provides that, in determining whether to give or withhold consent to loans, regard shall be had to any scheme or schemes legislated for in that measure. The Corporation, therefore, applied for rules to order the Commissioners to determine the application according to law and to quash the previous decision. In support of this application, it was pointed out that, by Section 13 of the Electricity (Supply) Act of 1922, the Commissioners could consent to the extension of a station if it were proved that a supply would thus be provided at a cost no greater than that of a supply available from another source, unless it was not necessary in the general interest of the electricity supply of the district. The question was whether that right was implicitly repealed by Section 18 of the 1926 Act. The Corporation submitted that it was not, and that, in refusing consent to the application, the Commissioners had acted without jurisdiction and had wrongly exercised their powers. This plea was rejected, however, and, in dismissing the application, Mr. Justice Charles said that the Court considered the Commissioners had come to the right conclusion.

The Association of Consulting Engineers.

The report of the Committee of the Association of Consulting Engineers, for the year ended April 30, 1940, shows that the membership now stands at 151, the highest figure in the 27 years of the Association's history. Five members resigned and one died during the year, but this loss was more than counterbalanced by the election of new members, who numbered 15. Even so, however, the report observes that there is a considerable number of consulting engineers, qualified for membership, who do not yet belong to the Association, although it is obviously desirable that a body of this kind should be as fully representative as possible. The first meeting of the 1939-40 Committee was held on June 5, 1939, when Mr. C. G. Du Cane, M.Inst.C.E., was elected chairman. At the outbreak of war, the office was temporarily transferred to Cheam, but has now been re-opened at the former address in Abbey House, Westminster. Mr. S. R. Raffety and Mr. Ranald J. Harvey continue to act as joint honorary secretaries. The report also summarises the principal objects of some proposed amendments to the articles of association, two of which are designed to permit the election to membership of certain qualified consulting engineers who are not technically eligible under the existing articles. Action has been taken by the Association to bring to the notice of Government Departments, especially those directly concerned with the prosecution of the war, the valuable reserve of skill and experience available in the ranks of professional consulting engineers.

The "Journal" of the Institution of Electrical Engineers.

Drastic paper rationing and a large increase in price have imposed a considerable disability on engineering institutions and, in particular, have made it more difficult to publish the proceedings on which their members so largely depend for information. Quite apart from these war-time conditions, however, the Council of the Institution of Electrical Engineers have felt for some time that the distribution of the complete *Journal* to each member was not the most satisfactory method of providing the required technical information owing to the highly specialised character of much of the contents, and had considered, therefore, its subdivision into "power engineering" and "communication engineering." As a further modification, it has now been decided that, from January next, each member will receive, instead of the present monthly issue of the *Journal*, a monthly copy of a "general division," which will contain fairly full abstracts of all papers accepted for publication, together with all material of general interest, such as progress reviews. The papers will appear in full with their discussions in two other separate divisions of the *Journal*, under the main headings of "power engineering" and "communication engineering," the former appearing six times a year and the latter quarterly. While the "general" division will be issued free, payment will be required for the other two divisions. The proceedings of the Wireless Section, which have been issued hitherto as a separate publication, in addition to being published in the *Journal*, will now be published in the "Communication Engineering" division only. Free advance copies of papers will still be available on application to the secretary. It is emphasised that the scheme is to be regarded primarily as a war-time measure and will be subject to reconsideration in the light of experience gained.

The Repair of War Damage.

It is inevitable that the framing of emergency legislation should occasionally fail to take into account all the factors which ought properly to condition its scope, and that amendments should be necessary to avoid unintended interference with essential work. The latest instance of the superiority of second thoughts is found in a recent order of the Secretary of State for War, to local authorities in England and Wales, in connection with the repair of war damage to property. Under the Control of Photography Order (No. 1), 1939, made under authority of the Defence Regulations, the making of any photograph, sketch or other representation of "any building, building structure, . . . or other object damaged by enemy action or as a result of steps taken to repel enemy action" is forbidden, unless sanctioned by a written permit granted by the Secretary of State or on his behalf. When the Order was made, it does not appear to have occurred to the draughtsman responsible that, not only did it prohibit a property owner from photographing his own damaged premises, but it forbade him to make any sketches or drawings necessary in making good the damage, unless with expressed individual authority from the Secretary of State or his representative. To cover such cases, general authority has now been given to the Clerks of local authorities to issue permits for this purpose; but it is provided that such permits are to be issued only to architects, surveyors and engineers who are British subjects by birth, and that no plans or sketches, made under the permits, may be published without the approval of the Press and Censorship Bureau. The authorisation does not extend to the taking of photographs of war damage, etc., and applications for permits for this purpose should be made to the General Officer Commanding-in-Chief of the Command in which the premises are situated.

THE WEAR-LOAD CHARACTERISTIC OF THE FOUR-BALL TEST WITH VARIOUS LUBRICANTS.

By Robert Schnurmann.*

The increasing importance of gear lubrication has led to numerous tests of lubricants, but their comprehensive physical interpretation has, so far, been impeded by certain unwarranted assumptions, such as the existence of a "breakdown load" of gear lubricants and of a "seizure characteristic" of the friction elements. The breakdown load is an arbitrary extrapolation of measurements of, for instance, the impression diameter observed with the four-ball apparatus, as a function of the load. The actual experimental result† with a ½-in. diameter ball rotating at 1,500 r.p.m. is that the diameter of impression increases with rising load, first almost linearly, then very rapidly, and tends finally towards a limiting value. In the intermediate range of rapid increase, the measured points are widely scattered. The assumption of an actual breakdown load was based upon the hypothesis that the surface irregularities penetrate adsorption layers and weld together, in spite of the fact that the measured diameters of impression lie above the Hertz line. It has also become customary for engineers to assume that seizure of the mating surfaces should be an indication of welded junctions between them, although this suggestion has no physical basis.‡ Even under conditions of load and speed of sliding which would lead to melting of the surface of the sliding component of lower melting point, the molten material would assume the function of a lubricant; no welding could be expected during a run. The lubricating properties of the molten material are, for instance, encountered in the slipperiness of ice near its melting point.

It might be argued that welding occurred towards the end of a run, when the previously molten surface layers begin to solidify upon reducing the speed of sliding, and, consequently, the rate of generation of frictional heat. Experience shows, however, that machine parts sometimes seize during service under extreme conditions, but that, under certain conditions, seizure can even occur during very slow motion, when the temperature of the mating materials has never risen above room temperature. Seizure as a physical property is rather ill-defined. Seizure load might, however, be defined as the load which cannot be exceeded without resulting in appreciable material damage to the sliding surfaces. This definition implies that there must be a continuous approach to conditions of "seizure"; there can be no sudden discontinuity, for instance, in the wear-load curve. The shape of every wear-load curve, and therefore also the shape of the impression diameter-load curve of the four-ball test, must be that of a saturation curve, as illustrated in the graph on the opposite page.

Starting from zero load, the surface asperities become more and more deformed, and the lubricant (or, when no lubricant is applied, the adsorption layers present on solid surfaces in the atmosphere) are gradually squeezed out during sliding, until only a thin film is left. In the extreme case this film is reduced to mono-molecular thickness and is very rigid. It will adhere strongly to the solid surface and, rather than rupture, will pluck out particles from the solid. The steep part of the wear-load curve occurs before this lower limit of film thickness is reached. While the boundary film becomes thinner and more adhesive, electrostatic actions and the oxidising action of the lubricant on the solid surfaces are contributory causes of wear. It was found, for instance,§ that the entire saturation curve was shifted towards the region of larger wear, if a neat cutting oil was replaced by a 5 per cent. emulsion of this cutting oil in water. This result was obtained with steel balls as mating surfaces,

* London Midland and Scottish Railway Company, Research Laboratory, Derby.

† D. Clayton, ENGINEERING, vol. 149, page 131 (1940).

‡ R. Schnurmann, *The Engineer*, vol. 168, page 278 (1939).

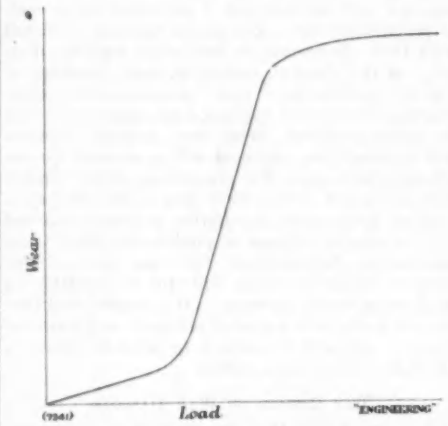
§ D. Clayton, *loc. cit.*, page 132, Fig. 3A.

and it seems possible to assume that the suspending water of the oil emulsion will lead to oxidation of the steel surfaces. It has been shown that oxidised surfaces have high coefficients of static friction, although their coefficient of kinetic friction may appear to be much smaller, because relative motion is transferred from the true boundary of the two materials and may occur either as shearing of the oxide layer, or plucking out of metal particles. It is in agreement with this interpretation that Clayton obtained still higher wear with distilled water as lubricant and actually observed rusting. Due to the small shear strength of the rust, the appreciable removal of material within a limited region of load may take place in fine particles, and there is thus no scoring or grooving. Scoring and rough wear prints are obtained with non-oxidising lubricants, such as kerosene and mineral oil, where the residual adhesive layer plucks out coarse particles, which are either crushed between the mating surfaces, or, if they are harder, either embed themselves or grind grooves; in the latter case they thus cause further wear. It is particularly this grinding action of hard plucked-out particles which would lead to rapid failure, and it is desirable to suppress it by choosing an appropriate lubricant and a suitable operating load.

The "breakdown load" is defined, in the case of the four-ball apparatus, as the load "at which seizure first occurs in the course of the one-minute run." The criterion for "seizure" is thereby an increase of the torque exerted by the loaded rotating ball upon the three mating spheres, which are connected with a spring dynamometer. It is interesting to note that there is no indication of seizure with certain extreme-pressure lubricants; for instance, with "E.P. Oil E," which can take "an extremely high load without welding." In this latter case, the coefficient of friction was quite small, $\mu = 0{\cdot}075$, even at a load of 510 kg., and the maximum coefficient of friction was $\mu_{max} = 0{\cdot}15$, whereas, with mineral oils and castor oil, the apparent coefficient of friction rose to about $\mu = 0{\cdot}5$ at considerably smaller loads. These results cannot be reconciled with the assumption of a "breakdown load," at which seizure due to welding should be experienced. If welding could conceivably be involved, the occurrence of seizure should depend upon load and speed of sliding. The apparent coefficient of friction would rise instantaneously upon formation of the welded junction, which subsequently would be ruptured when the reaction of the dynamometer spring exceeded the shear strength of the welded junction. The formation and rupture of welded junctions would then be repeated indefinitely, since the load and primary torque remain constant throughout the test. The friction-time chart should show periodic peaks upon reaching the "breakdown load," and the lubricant should be of much less influence than the material of the mating surfaces. Sir William Hardy* pointed out that conditions can arise, under which a lubricant becomes what he called an "anti-lubricant." This apparent metamorphosis is observed if the thin residual film of lubricant possesses a high dielectric breakdown strength. Otherwise, it will not easily acquire the behaviour of an "anti-lubricant" and incidentally, the order of increasing quality as regards wear established for gear lubricants by Clayton,† namely, mineral oils, fatty oils, and extreme-pressure lubricants, is the order of decreasing dielectric breakdown strength.

It is not always possible to make a clear distinction between the oxidising and dielectric properties of a lubricant. An interesting example of the joint action of oxidation and the electrostatic field built up during making and breaking of contact was observed by Clayton when rotating a single bronze ball in the cavity formed by three steel balls. Very slight marking of the steel balls was found, but there was a transfer of steel particles to the mating bronze ring unless a lubricant of relatively low dielectric breakdown strength had been used, such as extreme-pressure oil A. It appears that particles were removed from the mating component, which became oxidised, *i.e.*, from the steel balls, and that the fine abraded particles were deposited under the action of an electric field, which builds up during sliding until the breakdown value of the residual film is reached with following discharge and renewed building up of charges. The existence of such an electric effect under conditions of non-fluid lubrication was demonstrated by Kyropoulos,* who also found a deposit of abraded particles.

Whenever a liquid film is thinned out to a monomolecular layer, this layer must exhibit adhesive properties. The thinning out may either occur during sliding under sufficient load or without any sliding motion, if the contacting component is porous and thins out the liquid film through blotting action†. A piece of lump sugar, for instance, placed on an inclined glass plate (angle of inclination about 20 deg.) in the atmosphere, may slide a few millimetres and then come to rest, and it may be possible to increase the angle of inclination to about 35 deg., before the angle of repose is reached; whereas in a very dry atmosphere under otherwise equal conditions, an angle of repose of only about 10 deg. may be found. If, however, a drop of alcohol is allowed to spread on a horizontal glass plate and a piece of lump sugar is put on the wetted area, after allowing some time, say an hour, for the evaporation of the alcohol and the "blotting" of the film by the porous lump of sugar, the plate can be tilted, and the lump will stick to it, even at an



angle of inclination of 90 deg. The surface of a lump of sugar is very irregular, and the lump only adheres at the high points. Slight tapping of the glass plate may free the adhering lump, and it can then be observed that minute sugar particles remain sticking to the glass plate. It is not the adhesive film that has been ruptured, but the sugar surface has been torn.

At least one of three conditions must be fulfilled for wear to occur during sliding: either surface oxidation, or thinning out of a boundary film to make it assume adhesive properties, or the existence of an electric field. At high load and high speed of sliding, a considerable amount of frictional heat will be generated. Although, in most cases, the conduction and radiation of heat will prevent the mating surfaces from reaching the high melting points of bronze or steel, the temperature of the sliding components may rise appreciably. The chemical attack of the surfaces—for instance, their oxidation—must take place more rapidly at the higher temperatures. Therefore, the cooling effect of the liquid in the cup of the four-ball test apparatus will also influence the amount of wear encountered. The joint action of surface oxidation, adhesion of the residual film of lubricant, and contact electricity cannot lead to anything but very irregular friction-time charts. As has been pointed out, relative motion under boundary conditions does not always take place along the true boundary of the two materials, and conditions may arise under which the apparent coefficient of friction is controlled by the shear strength of the material or of its oxide layer.

In conclusion, the wear-load characteristic can be regarded as a guide for the selection of suitable gear lubricants for various mating materials and conditions of load and speed. The dielectric breakdown strength is one important property of a gear lubricant, if it is considered in connection with the oxidising properties of the lubricants on the mating surfaces. Oxidation may be beneficial within a certain range of loads, where it contributes to low continuous wear, as in such combinations as a steel worm and a bronze worm-wheel, where the transfer of fine oxidised steel particles may prevent the "pick-up" of coarse bronze particles by the steel worm, which would lead to scoring and rapid failure. The four-ball test imitates the "lubricating wedge" of a gear and seems to be a suitable apparatus for establishing wear-load characteristics, but its results do not prove the existence of a definite breakdown load of a lubricant.

* W. B. Hardy, *Nature*, vol. 106, page 569 (1920).
† D. Clayton, *General Discussion on Lubrication*, London, vol. 2, page 274 (1937).
* S. Kyropoulos, *Refiner*, vol. 18, page 273 (1939).
† R. Schnurmann, *Nature*, vol. 145, page 553 (1940.)

PROGRESS IN FEED-WATER TREATMENT.*

By C. H. FELLOWS.

TREATING water for use in steam-generating equipment is not new. The controlled application of scientific principles to the problems involved is, however, of comparatively recent origin. Although some new processes and new methods of application of the commonly used chemicals have been developed, the same basic object of the treatment of water for steam-generating purposes exists to-day under operating pressures of 600 lb. per square inch and higher as when pressures of the order of only 200 lb. and 250 lb. per square inch gauge were in use. There has been, during this development of higher-pressure operation, a marked change in the general conception of the importance of correct feed-water treatment, and, as a natural result, the exactness of the art has been stressed. Among the most important problems in the generation of steam at the present-day high-pressure operation are those of the chemistry of the materials. These concern principally the water used, together with its salts and gases, in relation to the confining metals. The solution of these problems lies, in a large measure, in the treatment of the water before it enters the boiler, in combination with additional treatment, in many instances, during the steam-generating process.

Purification of water began as simple settling of suspended matter. Then filtration followed, and chemicals designed to coagulate the suspended matter, to speed up settling and increase the efficiency of filtration, were introduced. Once started, this use of chemicals was rapidly developed to the point where they were employed to react with and precipitate certain of the scale-forming salts and permit their removal by settling or filtration before the water entered the boiler. To-day, depending upon the nature of the dissolved salts in the water and the use to which the steam generated from it is to be put, water may be treated outside the boiler, inside the boiler, or both outside and inside. Pre-treatment, that is, the treatment carried on outside of the boiler, may involve either the addition of chemicals and the subsequent removal of the reaction products by settling or filtration, or it may involve raw-water distillation, whereby only the condensed vapours are used as boiler feed-water.

The basic objects of feed-water treatment are: (1) The prevention of hard scale on the heating surfaces of the boiler; (2) the elimination of corrosion in all parts of the steam-water cycle; (3) the prevention or control of carry-over, to preclude adherent deposits in superheaters and on turbine blades; and (4) the inhibition of caustic embrittlement. Although these objects of feed-water treatment have not changed in the course of the development of steam-generating equipment, their significance in the overall efficiency of boiler operation is now being emphasised to a far greater extent than formerly. At the outset, it was sought to prevent the settling out of mud from suspended matter and the precipitation of scale from certain salts in solution. Little or no attention was given to corrosion in the early days of steam-boiler operation because, as a rule, the boiler surfaces were so coated with mud and scale that direct contact of the metal with corrosion-producing elements was not possible. Particularly in the case of certain types of raw water, and generally as the operating pressure was increased, it became necessary to prevent foaming and carry-over of boiler water with steam. This need stimulated the more careful use of treating chemicals and the reduction of the concentrations of dissolved salts and

* Paper presented at the Spring Meeting of the American Society of Mechanical Engineers at Worcester, Massachusetts, U.S.A., May 1 to 3, 1940. Abridged.

suspended matter in the boiler water. Efforts in this direction tended to reduce the amount of scale and mud deposited on the steam-generating surfaces, and, as a result, corrosion began to occur. The battle against corrosion in boilers has been waged actively during the last twenty or thirty years.

The maintenance of high alkalinities in the boiler water was long the principal means used in combating corrosion, and only within relatively recent years has the removal of oxygen, as a means of preventing corrosion, been practised to any major extent. At the present time, oxygen is considered to be the primary cause of corrosion in the boiler proper, although there have been manifestations of corrosion in high-pressure, high-temperature units that are obviously not entirely the result of oxygen in the water. Steps have been taken that have resulted in the practical elimination of dissolved oxygen, and a marked reduction in the severity of corrosion has been realised. In the superheater, however, with the nearly perfect elimination of oxygen in the boiler feed-water of central-station plants and in some of the large industrial plants, corrosion due to the dissociation of steam in contact with the hot metal, which gives rise to nascent oxygen or to the direct reaction between steam and the hot metal, is an important factor.

The practical manifestations of impure steam are (1) scaled superheater tubes, and (2) deposits on turbine blades of the soluble salts in the boiler water carried by the steam. C. W. Foulk and his associates at the Ohio State University have contributed much to our knowledge of the phenomenon of "carry-over." Present-day water-treating practices aim, in part, at the elimination of carry-over or its control to the extent that harmful effects of its occurrence are not evident. The prevention of "caustic embrittlement," the phenomenon of intercrystalline corrosion of highly-stressed boiler metal, has been, for 30 years, one of the least understood objects of boiler-water treatment. Its occurrence in the more modern high-pressure boilers has not, as yet, been observed. The reason, in spite of intensive investigations, is still a subject of controversy. Some hold that more careful fabrication and assembly than was possible in the case of the low-pressure boilers, and the concurrent use of welded construction and the practice of stress-relieving these higher-pressure units afford the principal reason, while others are of the opinion that boiler-water treatment has eliminated this type of trouble. Undoubtedly, both elements have contributed, although the older methods of chemical treatment obviously appear to be not entirely adequate in controlling intercrystalline cracking.

In nearly every instance in which boiler feed water is treated, the primary reason is to prevent the formation of hard scale on the heating surfaces. Fundamentally, most waters can be treated chemically to prevent scaling by the use of sodium carbonate, *i.e.*, soda ash, or one or more of the sodium-phosphate salts. Operating conditions generally dictate which shall be used. Sodium carbonate is used either as an internal treatment or as an adjunct in the hot or cold lime-soda external softeners, whereas phosphates are almost always used in internal treatments. Phosphate salts have other valuable properties in feed-water treatment besides their ability to prevent scale through reaction with the calcium and magnesium salts in the water. The phosphate ion has been considered by a number of chemists as a preventive of embrittlement. Moreover, the precipitated phosphate salts have the property of adsorbing small amounts of oil that may enter the system.

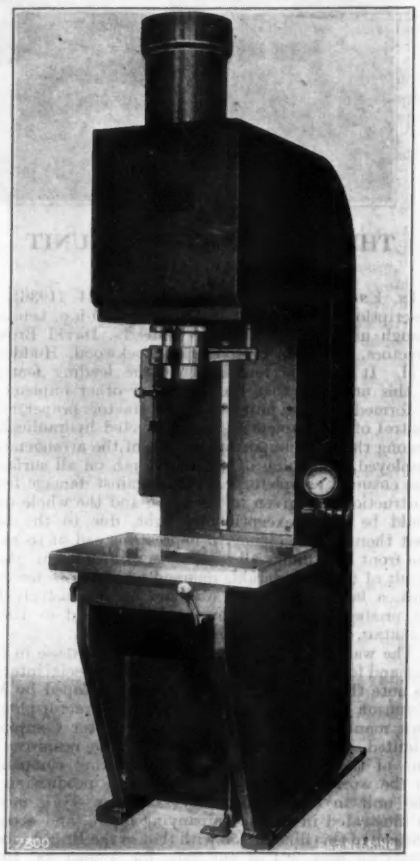
For scale-preventive treatment there are also the base-exchange processes using natural or artificial zeolites. A recent development is the acid zeolite. This zeolitic material liberates most of the potential carbon dioxide from the water. It is regenerated with sulphuric acid and is used in conjunction with the normal zeolites, which develop basic characteristics in the water and do not impart silica to it. Among this class of water-treating equipment is that one using synthetic resins as the exchange material. Manufacturers of such equipment report that, with the proper selection of exchange media, practically all of the salts in solution can be removed so as to produce virtually distilled water. The standard hot lime-soda softeners have been made more effective, first through the use of coagulants to remove more completely the scale-forming salts before the water enters the boiler, and second, because the use of phosphate as internal treatment assures more complete removal of residual calcium and magnesium.

(To be continued.)

MINERAL PRODUCTION IN QUEBEC.—During the first quarter of the present year 72,898 tons of asbestos, 250,623 oz. of gold and 281,480 oz. of silver were produced in the Province of Quebec, against 62,684 tons, 249,681 oz. and 281,751 oz., respectively, in the first quarter of 1939.

HYDRAULIC PRESSES WITH SENSITIVE CONTROL.

THE hydraulic press is being increasingly used in the United States for both straightening and press-fit operations. By the term "hydraulic" is meant not a press receiving a hydraulic supply from a central pump-accumulator system but a machine in which the hydraulic pump is actuated by an electric motor, the whole unit being assembled in the frame. The press is, therefore, self-contained and the only external connection required is the supply cable to the motor. The advantage of this individual pressure supply is that it is capable of more precise regulation. The degree of regulation provided in the range of hydraulic presses of which one size is shown in the accompanying illustration, is secured by a new type of sensitive pressure control, a feature which renders the presses particularly suitable for straightening operations. The press illustrated has a capacity of 25 tons and is constructed by Messrs. Hannifin Manufacturing Company, 621-631, South Kolmar-avenue, Chicago,



Illinois, U.S.A., this firm being represented in Great Britain by Messrs. Broadway Engineering Company, Carlisle-road, Hendon, London, N.W.9.

The frames are of welded steel, a construction which admits of flexible design for different gaps, table arrangements, etc. Thus, the machine illustrated has a plain table with a surface measuring 30 in. by 22 in., and 40 in. from the floor, but the machine can be supplied with the two supports widened at the top to carry two sections of table 10 in. in depth, between which is a removable section. This can be slid out, leaving a gap reaching to the floor, or it can be used in place for press-fit work. The two side sections, being fully supported, can be used to carry fixtures for shaft straightening. The overall length of such a table can be 50 in. or more. The gap, *i.e.*, the height between the table and the bottom of the ram in its highest position, is 25 in., and the distance from the centre of the ram to the face of the column is 15 in. The ram stroke is 24 in., but it can be varied by limiting the length of the return stroke, so eliminating unnecessary travel.

The movement of the ram and the pressure it exerts are both controlled by the single lever seen in front of the table, which lever, normally hand operated, is coupled up to a pedal so that foot operation is also practicable. The operating cycle is as follows: The lever stands in its upward position, as shown, between operations, the ram remaining at the top of the cylinder and the oil pump idling at zero pressure. Movement of the lever downwards, through about 1 in. of knob travel, causes the ram to move downwards at a rapid rate. If the lever is left in this position the ram will descend until it touches the work, at which point it will stop. The pressure exerted during this traverse is barely discernible on the gauge. Further depression of the lever from this approach position applies the actual straightening or pressing load to the ram, the pressure exerted being proportional to the distance through which the lever is moved. Any pressure up to the full capacity of the press is thus obtained by moving the control lever downwards. Release of the lever at any point causes the ram to return automatically to the top of the cylinder at a speed of 157 in. per minute, the power stroke being made at the rate of 83 in. per minute. The hydraulic power unit is driven by a 10-h.p. motor.

Other sizes of press in this series include a 35-ton press and a 75-ton press. The same power unit is used in each case, the speeds being, in consequence, less; thus the 35-ton press may have a power stroke of 6 in., for straightening operations on heavy bars, at a speed of 53 in. per minute and a return stroke of 83 in. per minute, the corresponding figures for the 75-ton press being 12 in., 24 in. per minute, and 40 in. per minute. In one design of the 75-ton press the table is 12 ft. long and the distance from the centre of the ram to the face of the column is 36 in. It must be understood, however, that these dimensions are typical only, all the presses being capable of constructional modification within reasonable limits to suit particular classes of work.

WAR-TIME BUILDING CONSTRUCTION.

IN view of the need for maximum economy in the use of steel for building at the present time, a committee on alternative materials and methods of construction, whose chairman is Mr. G. M. Burt, has recently been appointed by the Department of Scientific and Industrial Research. As, however, the employment of steel cannot be altogether excluded for this purpose, the next best thing is to ensure that, consonant with safety, as little as possible of this material is used. For that reason, a number of designs which, it is hoped, will be useful to architects and others, have been prepared. These designs have been published in a pamphlet entitled *Wartime Building Bulletin No.* 1, which can be obtained from H.M. Stationery Office at the price of 1*s.* net, and represent a drastic cutting down of all superfluous metal.

They are intended for multiple-bay factory construction only and are based on such fundamental problems as those of supply, of lighting and of economy, in conjunction with maximum stability against air attack. Economy of steel for this purpose is, of course, tied up with the dimensions of the bays. Thus, long spans generally can only be obtained by increasing the quantity of steel. To some extent, therefore, requirements of space must be modified without impairing productive efficiency more than is absolutely unavoidable. Naturally, the success of any efforts in this direction must depend on the full co-operation of the controllers of the factories, who know best how to adjust the lay-out of plant and other factors in the interests of economical construction. The designs given in the Bulletin are some of a number prepared by a Committee of the British Steelwork Association, those which were less economical and less suitable from the point of view of air-raid protection having been rejected. This question of air-raid protection is, of course, dealt with in detail, a number of useful recommendations being made regarding the degree of protection required, to minimise the effect of a direct hit by sectionalising the structure, to the treatment of glazing, and to camouflage.

In particular, the designs relate to single-storey, open-shed type factories, a range of bay sizes being provided which should be suitable for most requirements. Two alternative heights, 12 ft. 6 in. and 15 ft., are given, with a maximum span of 40 ft. Three types of structure are covered. The first, known as Type A, is a monitor roof design giving overhead protection, consisting of a 4-in. reinforced-concrete slab. The simple supporting structure consists of stanchions with main and secondary beams requiring the minimum of fabrication and capable of very rapid erection. Type B is a simple symmetrical truss with an extension of the principal rafter on one side to provide a panel of vertical glazing. The trusses are supported by a valley girder resting on stanchions. Type C consists of symmetrical umbrella-type trusses supported by a lattice girder on stanchions at the centre. With a view to economy, continuous beams, combined with virtual pin connection in pre-determined positions supporting short suspended spans, have been adopted. This, it is considered, will necessitate the reduction of the spacing between the stanchions and the external walls in the end bays. Pains have been taken to reduce the area of glazing to a minimum,

both on the score of air-raid protection and the black-out, and for the latter reason, too, it is assumed that ventilation will be provided by roof ventilators and fans.

Bulletin No. 2, the price of which is 6*d.* net., gives data showing how, when the single-storey flat-roof designs mentioned in the first Bulletin are used, reinforced concrete may be employed to reduce the weight of steel required to only one-half or one-third of that needed for a steel structure. A diagram indicates the relation between the weight of steel per 100 sq. ft. and the spacing of the vertical supports for various types of construction. For reinforced concrete, spans of from 20 ft. to 30 ft. are found to be the most desirable. Some suggestions are made for utilising the limited supply of shuttering material to the best advantage. For instance, unnecessary architectural features, such as recessed panels and plinths, should be eliminated or reduced, and form work should be stripped at the earliest moment consistent with safety. Shuttering could also be saved by the use of systems of pre-cast construction, although the cost would be higher.

It is emphasised that reinforced-concrete buildings must be erected only under expert supervision by firms specialising in this type of work.

LETTER TO THE EDITOR.

INFLUENCE OF SIZE ON THE FRACTURE OF NOTCHED-BAR TEST PIECES.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of May 24, on page 530, Professor Cook points out that, even in plastic straining, larger and smaller test pieces do not give results in rigorous agreement with Thomson's Principles of Mechanical Similarity; and he attributes this to the influence of stress-gradients in relation to grain size. I do not doubt that this explanation may be correct in many instances, nor that comparable deviations arise also from other influences; for example, from "fibre" in rolled steel, from residuary effects of ingot structure, thermal contractions and surface decarburisation. In fact, it has long been customary to investigate such influences—as in the "Prism" hardness test—by using Thomson's principles as a basis of comparison.

The case of cracking differs, as I believe, only in that we have not yet succeeded in identifying or overcoming the cause of the "scale effect" which, in this case, is greater and of far greater practical importance, particularly in time of war. Notches, in notched-bar tests, are specially designed to produce stress-gradients and their varied effects; but it seems unlikely that stress-gradient provides a sufficient explanation of the deviation in question, from ductile tearing in small test pieces to brittle cracking in larger. Part of the difficulty may be illustrated by the following contrast: (*a*) When bars of the same size are tested with different notches, the sharper notches produce steeper stress gradients, and, also, more brittle forms of fracture. (*b*) When bars of different sizes are tested with geometrically similar notches, as in the demonstration at Greenwich mentioned by Professor Cook, the larger pieces break in more brittle manner, although the stress gradients are less steep, inversely in proportion to the linear dimensions.

It may be not impossible that change of stress-gradient relatively to grain-size might thus produce opposite effects in cases so closely related; but it seems more probable that the difference arises from some other cause.

Yours faithfully,
B. P. HAIGH.

Royal Naval College,
Greenwich. May 29, 1940.

BRITISH DIESEL ENGINES IN AUSTRALIA AND SOUTH AFRICA.—Messrs. Petters, Limited, Loughborough, who supplied the first engines to be installed by the Burra Electricity Supply Company, Australia, in 1924, have recently supplied a three-cylinder 187·5-brake horse-power Superscavenge Diesel engine which is coupled to a 125-kW Harland alternator. Messrs. Petters have also recently slipped to South Africa a six-cylinder 375-brake horse-power Superscavenge Diesel engine. This order was placed by Messrs. Reid Brothers (South Africa), Limited, and the engine will be installed in one of the mills of the Tongaat Sugar Company, where it will be directly coupled to a Brush 242-kW (0·8 power factor), 550-volt, 50-cycle alternator. The alternator is directly coupled to the engine flywheel. Our readers will be familiar with the characteristics of the Petter Superscavenge Diesel engines, which have been described in our columns on several occasions.

FERGUSON-FORD UNIT TRACTOR.

MESSRS. FORD MOTOR COMPANY, LIMITED, DAGENHAM.

THE FERGUSON-FORD UNIT TRACTOR.

IN ENGINEERING, vol. 142, page 224 (1936), a description was given of the Ferguson 20-h.p. tractor-plough unit, manufactured by Messrs. David Brown Tractors, Limited, Park Works, Lockwood, Huddersfield. It may be recalled that the leading feature of this unit was that the plough or other implement is formed in one unit with the tractor proper, the control of the implement being effected hydraulically. Among the more important results of the arrangement employed, ploughing of uniform depth on all surfaces was ensured, complete protection against damage from obstruction was given to the tools, and the whole unit could be made exceptionally light, due to the fact that there is a tendency to depress instead of to raise the front axle under all conditions of operation. As a result of the considerable demand which arose for this unit, a large new works was laid out exclusively for its production. This works was described in ENGINEERING, vol. 147, page 51 (1939).

The war has resulted in a very large increase in the demand for tractors, and it is therefore of special interest to note that the hydraulic principle developed by Mr. Ferguson has now been applied to a tractor-plough unit manufactured by Messrs. Ford Motor Company, Limited, Dagenham, Essex, so that the resources of one of the largest tractor manufacturing companies in the world are now available for the production of the unit in large quantities. The new Ford model is illustrated in the accompanying figure, and a comparison of this illustration with that of the Brown model given on page 224 of our issue for August 28, 1936, will show that the mounting of the implements is identical in the two cases. The description of the hydraulic machine in the earlier model, given in the article referred to, therefore, equally applies to the Ford unit. As regards the tractor proper, the engine is the four-cylinder L-head type with a cylinder bore of 3·18 in. and a piston stroke of 3·75 in. The recommended ploughing speed is 1,400 r.p.m., at which speed the power developed is 23 brake horse-power. A variable-speed governor is fitted, controlled from the steering column, giving a range of 1,200 r.p.m. to 2,200 r.p.m. Lubrication is by gear pump supplying oil under pressure to the crankshaft, camshaft and connecting-rod bearings, and also to the timing gears. Battery ignition is employed, the distributor forming a unit with the coil in a waterproof housing. The spark advance is automatic. The cooling water is pump circulated, the pump being of the glandless type with pre-lubricated bearings. An air cleaner of the oil-bath type is fitted. The power is transmitted through a single dry-plate clutch with an effective diameter of 9 in. The gearbox provides three forward gear ratios and one reverse ratio, the forward ploughing speeds with the engine running at 1,400 r.p.m. being 2½ m.p.h., 3 m.p.h., and 6 m.p.h. The reverse speed, at the same engine revolutions, is 2½ m.p.h. All the shafts in the gearbox are mounted on taper-roller bearings. The final drive is of the spiral-bevel gear type with a ratio of 6·66 to 1. A four-pinion differential is fitted, mounted on taper-roller bearings. The driving axle is of the semi-floating type with the axle shaft and wheel hubs integral, also carried on taper-roller bearings. Independent brakes of the internal expanding type are fitted to each rear wheel, control being by separate pedals to facilitate a quick turn. The wheelbase is 70 in., and the normal tread, for both front and rear wheels, is 48 in. The front tread is, however, adjustable by means of a telescopic beam and reversible wheel discs from 48 in. to 76 in. in 4-in. steps. The rear tread is also adjustable by means of reversible wheel discs and reversible rims over the same range. The ground clearance is 13 in. under the tractor casing and 21 in. under the axles. The minimum turning circle is 15 ft.

THE NEW SOUTH WALES DEPARTMENT OF WORKS.

WHILE war needs are certain to have accelerated industrial expansion in many Australian districts, the rapid pre-war growth of the coal- and iron-producing area centring upon Port Kembla is especially discernible in the report recently issued by the Department of Works of the New South Wales Legislative Assembly, covering the year ended June 30, 1938. Continued extensions made to the breakwaters have improved conditions within the harbour; and, to deal with increasing shipments from the port, a new timber jetty, suited to the rapid loading of either coal or general cargoes, is being built. Extensions have been made to the electric generating plant and buildings, and, at the end of the year, the second of two new 5,000-kW turbo generators was being installed; an additional 7,500-kW unit, together with accessory plant, had already been tendered for. The demand for electric light and power continues to grow throughout the State, and many electricity undertakings were extended by the Department during the year.

Among architectural works, upon which a total of 929,084*l.* has been expended, is an engineering school, to be built at the Sydney Technical College, at a cost of 120,000*l.*; and new engineering workshops at the Newcastle Technical College, to accommodate classes in electricity, welding, blacksmithing and boiler-making. A complete sewerage scheme is being carried out at Maitland, this being one of various water-supply, sewerage and storm-water drainage schemes on which the Department is spending a total of 3,192,400*l.* Constructional and maintenance work to harbours and rivers cost 1,698,525*l.* Altogether, 2,146,883 tons of material have been dredged during the year; the sharp rise in the cost per ton, from 9·04*d.* in the previous year to 13·47*d.*, is accounted for by the major overhauls of dredgers and other plant. At Newcastle, 9,409 cub. yd. of rock were broken in deepening an entrance channel, 250 ft. wide. At Long Bay, in Sydney Harbour, as an unemployment-relief scheme to provide a large recreation area, reclamation work involved the construction of a reinforced-concrete box channel, erected on pile or rock foundations, and also the construction of roads leading to the area from adjoining municipalities. In the metropolitan area, alone, 502,925*l.* was spent on road construction. Much of the constructional work, such as road-making, sewerage, reclamation and drainage, is carried out by local governing bodies.

LABOUR NOTES.

On Friday, last week, representatives of the Railway Executive Committee and representatives of the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Railway Clerks' Association reached agreement on the application of the men's organisations for a further increase of wages. The terms of settlement provide for an advance of 3*s*. a week on the war wage now being paid to men in the traffic grades, with proportionate amounts to juniors and women, and an increase of 8*l*. a year to men clerks. Since the beginning of the year, men in the traffic grades have received a total increase of 7*s*. a week, and junior males one of 3*s*. 6*d*. a week; women have received a total increase of 5*s*. 3*d*. a week, and junior females one of 2*s*. 9*d*. a week. Of the salaried staffs, men have received an addition of 18*l*. a year, junior males one of 9*l*. a year, women one of 5*s*. 3*d*. a week, and junior females one of 2*s*. 9*d*. a week.

The National Committee of the Amalgamated Engineering Union, which met at Morecambe last week, is the organisation's most important central body. Its members are elected annually by the branches, and their decisions, in effect, determine the policy of the union. In their report to the committee, the executive council said that the absorption of the organisation's unemployed members by the demand for armaments was "now accomplished" and that when the manufacture of warlike goods reached its peak it would probably be found that there was not sufficient man power remaining to meet the requirements. If the industry were unable to cope with the demands for personnel, the question of a great influx of women was bound to arise, and they could not dissociate themselves from the rates and conditions under which the women would be employed. If women were placed in competition with semi-skilled men engaged on simplified operations, they should receive similar rates and conditions; otherwise the inducement to employ women would be obvious.

Addressing the committee, Mr. Tanner, the president of the union, said that the conflict which was now in progress was an engineers' war—"a machine war with a vengeance." Behind the anti-aircraft defences, and the machines on land and sea and in the air stood the engineer, and without his help there could be no talk of overthrowing Nazi-ism. "We shall be tried and tested," Mr. Tanner declared, "to the utmost of our courage, capacity and understanding." There had not been, he went on to say, a proper and complete utilisation of the skill of their members in the Services. There had been a criminal waste of rare and precious engineering labour, and they had not been successful in getting more than 100 men returned to industry.

A resolution was submitted—and eventually adopted—to apply for a wage increase of 3*d*. an hour. In the course of the discussion, Mr. Tanner said that Mr. Bevin, the Minister of Labour, proposed to put before his Consultative Committee—which is composed of representatives of the Trades Union Congress and the British Employers' Confederation—the whole question of wage adjustments. It might be that all factories engaged on munitions and armaments, or other war work, would be controlled. It was possible that the Government would take further steps in the direction of limiting or even eliminating profits. A different method of discussing wage adjustments might be adopted. There would, possibly, be a court, representative of workpeople and employers—perhaps with the Government as the employer—with an independent chairman. According to Mr. Maloney, another member of the executive, the Minister of Labour has in view the fixing of an "appointed day" after which wages will be regulated in a manner which is still to be determined.

At its meeting on Wednesday, the National Committee endorsed the agreement with the employers permitting the extension of the employment of women in the engineering industry. At the same time, a proposal was adopted to the effect that in order to preserve the interests of displaced men workers, the executive council should seek statutory safeguards from the Government as to the operation of the agreement after the war. Mr. Tanner pointed out that Mr. Bevin had voluntarily expressed his feeling that the skilled men who were making sacrifices should have their positions safeguarded. Women are not, of course, eligible for membership of the Amalgamated Engineering Union, but the Rules Revision Committee of the organisation—which is to meet shortly—is to consider a proposal that they should be.

Addressing the committee on Thursday, Mr. J. C. Little, a member of the Labour Supply Board, and an ex-president of the Amalgamated Engineering Union, said:—"Get back to work as quickly as you can and stay at it, because I believe that the salvation of our democratic institutions and of our country is completely dependent on your efforts in the workshops. It is not the people at the heart of the Government; it is not Parliament that will win this fight—it is the soldiers, and they cannot do it without adequate equipment."

Outlining the Minister of Labour's scheme for speeding up production, Mr. Little said there were to be area control boards under divisional controllers. These boards would be for the following areas:—Southampton and Reading (Southern); Bristol and Gloucester (South-Western); Birmingham, Coventry, and Rugby (Midlands); Leicester and Nottingham (North Midlands); Manchester and Liverpool (North-Western); Sheffield and Leeds (North-Eastern); Newcastle (Northern); Swansea and Cardiff (Wales); Edinburgh and Glasgow (Scotland). Inside those areas there would be an area officer and so many inspectors, and in the bigger areas several assistant inspectors. Altogether, there would be 400 inspectors at a salary of 600*l*. a year.

A resolution, expressing alarm at the amount of excessive overtime that is being worked, was adopted by 22 votes to 17. The member—a London representative—who moved it, said that even during the war period, it was necessary to maintain some control of overtime.

The Minister of Labour appealed last week to all owners of maintenance workshops and the men employed in them to arrange for the release of skilled men for more essential war work. "I am sure," he said, "that there are many jobs where work could be so arranged that skilled fitters or tool-room workers, for example, could be released either permanently or temporarily for work on more essential production. I am not asking that anyone should leave his present job until there is another job for him to go to, but I appeal to firms with maintenance shops to discuss the matter with their skilled workers and to tell the local employment exchange what they would be willing to do. They should give the employment exchange the names and addresses and occupations of the men who are willing to go and whom they can spare."

"Even a temporary loan of skilled labour," Mr. Bevin continued, "is important at the present time, and I ask the employers concerned to consider whether some of their maintenance work cannot, without serious danger, be postponed so that the skill of their men may, if required, be available for vitally urgent work in the national interest. In this way I want, while keeping maintenance for all industry intact, to have local reserves of skilled labour which I can borrow to help out when war demands cause situations of great urgency. At the same time I want this dealt with in a thoroughly systematic and organised manner."

It is announced that in order to increase the opportunities for training men for the munitions industries, the Ministry of Labour is opening additional training centres and enlarging some of the existing centres. More instructors are urgently needed. These instructors are wanted in the trades of fitters, machine operators and instrument makers. They must be skilled craftsmen, and ability to lecture to students will be an advantage.

In the course of a message to industrial workers on the subject of holidays, Mr. Bevin appeals for a seven-day week for some time to come. Rest periods, he admits, there must be, for health and efficiency demand them; but holidays that break into production are impossible, he says, in the present grave emergency. In particular, he asks for the abandonment of the town holidays, usually lasting for a week, which are customary in the industrial areas of the North and the Midlands.

The Employers' Federation of New South Wales addressed a letter to the Commonwealth Government in which, while fully subscribing to the principle that employees who enlist should be guaranteed reinstatement on termination of their war service, the Federation raised the question of the practical application of this principle in certain circumstances. If a temporary employee, taken on to replace a permanent employee who had enlisted, should also decide to enlist, would the employer be under an obligation to reinstate both the temporary and the permanent employee? The Government, in reply, expressed the opinion that the obligation of the employer would be discharged by reinstating the former regular employee. Consideration would, however, be given to the desirability of amending the regulations on the point in question.

THE DRAGLINE EXCAVATOR.*

By WILLIAM BARNES, M.I.Mech.E.

SHORTLY after the commencement of the Twentieth Century, a contractor, when digging a canal in Chicago, fitted a scraper bucket to a power derrick. That application of mechanical power to a modified form of horse-drawn scraper-pan or bucket was the commencement of the dragline excavator as it is known to-day. The mechanism was crude and it is only within recent years that engineers have realised some of the many uses and advantages of this type of single-bucket excavator. The purpose of this paper is to enumerate and comment on these uses and advantages.

One of the great advantages of a dragline, compared with the power shovel, is that it stands on the surface of the ground and digs below its own level. Thus, it was at first used mainly for underwater work, such as the cleaning out and widening of rivers, drains, and canals. The dragline excavator is now, however, used extensively for jobs where the power shovel was, at one time, the accepted machine. Compared with that of a power shovel the boom of a dragline is very much longer, and stability has to be considered more carefully. The working load, that is to say, the weight of the bucket and contents, should not exceed two-thirds of the tipping or overturning load, which takes into account the swing of the bucket beyond the boom-head radius, when dumping under certain conditions. The boom can be easily varied in length, and the working radius altered by means of the boom-hoist gear, which should always be incorporated. A longer radius than that recommended for the standard bucket can be used if the loading at the boom head is decreased by fitting a smaller bucket, but the effects of such changes must be very carefully considered, as otherwise the working speed and balance of the machine will be adversely affected. Counterweight at the rear of the machine provides the necessary stability, but adds weight to the machine, and necessitates either a decrease in the slewing speed or an increase in the power required for slewing. On the modern dragline, the machinery is placed behind the centre-post, where it acts as counterweight.

The dragline is usually employed as an excavating unit, but sometimes, because of its long dumping reach, it is used both to dig and to transport the material. The dragline is a useful and adaptable machine, and improved design has added considerably, in recent years, to its many useful applications. For instance, not long ago the recommended maximum digging depth was only about one-half of the boom-head radius or length of boom. Now, however, digging depths equal to the boom-head radius are not at all unusual, and depths 50 per cent. greater than the boom-head radius are being dealt with by fitting much longer booms and using buckets of improved design. Less than ten years ago, the longest boom-length available on a standard ¾-cub. yd. machine was 28 ft., whereas 50-ft. booms are now available on this size of machine, in conjunction, of course, with smaller and lighter buckets. At one time, draglines were capable of digging only comparatively easy material; now, however, they are being used for really heavy material containing rock, and may even be used for excavating rock itself when it is sufficiently blasted and broken up, and when a machine large enough for the job is employed.

The digging efficiency of a dragline depends considerably upon the design of the bucket. Manufacturers, at one time, were content with one design or type of bucket, irrespective of the work the machine would be called upon to do, whereas, at the present time, four different types and weights of buckets are usually obtainable, as follows: (1) a standard bucket, for average digging; (2) a light bucket, for easy digging; (3) an "ultra-light" bucket, on small machines, for removing mud and soft materials from rivers and drains; and (4) a strong heavy bucket for digging very heavy material, including rock or minerals. This last type is available only on medium-sized and large machines when the power available is sufficient for heavy duty. In the latest type of standard dragline bucket, all-welded construction has replaced riveting, and this, together with scientific design, has produced a much stronger bucket than those previously used, although weighing between 25 per cent. and 30 per cent. less. Flat plates, although heavy, offer very little resistance to bending or twisting stresses, so in the new bucket the body plate has been reduced in thickness and then strengthened by welding stiffeners where the greatest stresses and wear take place. Square-section rubbing pieces are also welded on to the underside of the bucket to protect the body plate as it is dragged along the material under excavation. The absence of internal rivet heads results in a smoother and cleaner surface for both digging and dumping. A weak feature of the old bucket was the tendency for the sides to

* Paper read before the Institution of Civil Engineers on Tuesday, February 20, 1940. Abridged.

pull in at the front, where the drag chains are attached. An all-welded box-section arch and a cast manganese-steel lip now greatly stiffen the front of the bucket. The lip has sockets holding renewable and reversible alloy-steel or high-carbon steel teeth. Wear on the pins and shackles attaching the drag and hoist chains to the bucket and rope connections is severe. Large circular links of alloy or manganese steel are fitted on the new buckets, to distribute the pressure and reduce the wear. Floating bushes on the bale-lug pins, special quick-change renewable steel links, and other details are all the result of careful field studies.

There are several advantages in being able to choose a bucket to suit the nature of the digging. For example, if a standard bucket of 1 cub. yd. capacity and weighing 2,250 lb. is used for digging stiff moist clay weighing 3,000 lb. per cub. yd., the gross load is 5,250 lb. This can be assumed to be the safe working load. Supposing, however, that the same machine is required to dig loamy soil or easily-excavated dry clay weighing 2,200 lb. per cub. yd., then a 1¼-cub. yd. light-type bucket weighing 2,270 lb. can be used, as the 1¼ cub. yd. of material will weigh only 2,750 lb.; the gross load will therefore be 5,020 lb., compared with the gross load of 5,200 lb. when using the 1-cub. yd. standard bucket in heavy clay. As the loamy soil is easy to dig, the 1¼-cub. yd. bucket can safely be used. It will be seen, therefore, that, by changing the bucket at a comparatively small cost, 25 per cent. greater output is obtainable. Sometimes digging and dumping radii are of greater importance than output. An example is a dragline with a working radius of 40 ft. using a 1-cub. yd. standard bucket weighing 2,200 lb. in material weighing, say, 2,500 lb. per cub. yd., giving a gross load of 4,700 lb. On most drain- and river-clearance jobs, a light-type bucket will readily handle the material, so that if a 1-cub. yd. light-type bucket weighing 1,900 lb. is substituted for the 1-cub. yd. standard bucket, it is quite practicable to increase the radius to 45 ft., which may be a considerable advantage. A wide range of dragline buckets is available, capacities ranging from ¼ cub. yd. upon a machine weighing 7 tons to 20 cub. yd. upon a machine weighing 1,200 tons.

Formerly, all booms upon machines up to about 1¼ cub. yd. bucket-capacity were constructed of mild-steel channels, and, upon larger machines, of mild-steel angles with riveted lattice bracings. Riveting has now been replaced by welding, and this, with improved design and modern material, has reduced the weights of the booms. The boom fittings, especially the boom-head connections and pulleys, have also been reduced in weight. Better balancing of machines has also helped the adoption of longer booms. The modern boom is usually built up of a number of sections, so that its length can easily be altered to suit different working conditions. For instance, the standard length of boom upon a certain machine is 60 ft., and it is constructed of two sections; it carries a bucket of 2½ cub. yd. capacity. The same boom can, however, be increased in length to 70 ft., 80 ft. or 90 ft. by adding sections 10 ft. long, bolted between the two main sections, to take buckets of 2, 1¾ and 1½ cub. yd. capacities, respectively. This is useful, when, on different parts of the same job, greater or smaller digging ranges are required.

Given a definite boom-length and a modern bucket, the maximum digging depth is dependent almost entirely upon the nature of the material, including its hardness or the resistance it offers to the bucket teeth and its natural angle of repose, as shown in Fig. 5, opposite. In this diagram three representative materials are shown, viz., wet running-sand, dry loam or similar material very easy to dig, and dry clay. Wet running sand is a difficult material to deal with because as fast as the material is dug from the toe and the face it "flows" to a flat angle of repose which greatly limits the digging depth. The longer the boom the greater is the possible digging depth. In the diagram the bucket in running sand is shown thrown well out beyond the boom-head radius, which is good practice for certain jobs, not only in shallow digging, but in faces with a normal depth. It is only possible to excavate the dry clay shown at the steep angle if the material is not too hard to be dug with the bucket resting on the face at that angle, since the pressure upon the teeth due to the weight of the bucket is, comparatively speaking, very small. That digging to about this depth is practicable is proved by a dragline, with 70-ft. boom and 1½-cub. yd. bucket, which is digging clay to a depth of over 100 ft. near Bletchley.

From Fig. 1, Plate XXXI, it will be seen that the bucket can be thrown out well beyond the boom-head to increase the digging radius, thus enabling a wider cut to be taken. The length of throw beyond the boom-head, which can easily be 30 per cent. greater than the boom-head radius under favourable conditions, depends, to some extent, upon the depth of the excavation or surface of the water below the working level of the machine. For dumping into wagons, the dumping radius is equal to the boom-head radius, as the bucket is suspended vertically from the boom-head by the hoist rope. For dumping to spoil or back into water the bucket can, however, be swung out several feet beyond the boom-head. The bucket can be dumped at any height from a point immediately under the boom-head to a reasonable distance below the working level of the machine.

The digging power should bear a definite relation to the capacity of the bucket, and the speed should be as high as is consistent with control of the bucket during the progress of the cut. If the speed is too high, the bucket cannot be filled efficiently. Modern practice indicates that, in average material under average digging conditions, the drag pull, which is approximately the digging effort upon the bucket-teeth, should be between 16,000 lb. and 18,000 lb. per cubic yard of bucket-capacity for small machines, approximately 14,000 lb. per cubic yard for 3-cub. yd. machines, and approximately 12,000 lb. per cubic yard for 12-cub. yd. machines, with digging speeds between 140 ft. and 180 ft. per minute. To avoid loss of time in dumping, the hoisting and slewing motions should be carried out simultaneously so that the correct dumping height coincides with the end of the swing. For high dumping, either on to a bank or into a hopper, the bucket has to be hoisted higher during the slewing period. Since slewing speeds are faster on modern machines, the hoisting speed has been increased from about 110 ft. per minute to 150 ft. to 200 ft. per minute.

Another valuable feature of the modern dragline is the provision of interchangeable drum laggings of different diameters, by means of which the digging pulls and speeds and also the hoisting speeds can be altered to suit different digging conditions. For very deep digging, large-diameter drum laggings are available to avoid, as far as possible, coiling the rope in more than one lap or layer. This increases the digging and hoisting speeds and proportionately decreases the digging and hoisting pulls, but this is not always a disadvantage as, because of the deep face, a thinner cut, requiring less cutting effort, is taken to fill the bucket over the longer distance resulting from the deep face. A smaller bucket is also usually employed, because of the longer boom which is necessary to deal with the deep cut. The reduced drag and hoist pulls are therefore sufficient for the smaller bucket and a comparatively fast operating cycle is maintained, even in the deep face.

Internal-combustion engines or electric motors are used, almost exclusively, for the motive power. In practice it is found that larger average outputs are obtainable from excavators driven by electric motors or by internal-combustion engines than from steam machines. Field records show that the net working time, with steam as the motive power, averages from 65 per cent. to 75 per cent. of the gross working hours, compared with from 85 per cent. to 90 per cent. with internal-combustion engines and from 90 per cent. to 95 per cent. with electric motors. For use in permanent situations, such as pits and quarries, electricity is usually favoured. The recognised practice for draglines with buckets up to 2 cub. yd. or 2½ cub. yd. capacity is to fit a continuously-running internal-combustion engine, or electric motor, and to drive all the various motions through friction clutches. Modern clutches are very efficient, both for easy operation and long life, with consequently low maintenance costs, which probably accounts largely for the fact that at least 95 per cent. of the excavators now constructed are clutch-operated. The remainder consists chiefly of large machines fitted with Ward-Leonard electric control, the digging and hoisting motions being, however, controlled through power-operated clutches. In order to obtain the greater digging power and operating speeds characteristic of modern machines, larger power units per cubic yard of bucket-capacity are now employed, so that the horse-power now ranges from 70 to 90 per cubic yard of bucket-capacity, compared with about 50 to 60 on early models.

Caterpillar tracks, self-laying tracks, or crawlers, though most useful for excavators, add from 25 per cent. to 35 per cent. to the cost of an excavator, compared with rail wheels, but from their increased mobility and economy in time and labour they have replaced entirely rail and road wheels. The usual bearing or ground pressure on caterpillar tracks varies from 10 lb. to 15 lb. per square inch, which is suitable for travelling on ordinary ground. For soft ground, longer and wider tracks are used to reduce the bearing pressure to 7 lb. to 10 lb. per square inch. For power shovels, long tracks are not advisable, but with a dragline it is possible, and frequently desirable, to use long and wide tracks. With soft marshy ground alongside a river, too soft even for oversize Caterpillar tracks, timber mats or rafts should be used. These result in a low bearing-pressure of the order of 2 lb. to 5 lb. per square inch, depending upon the mat area and machine size. The foregoing remarks refer to draglines up to about 80 tons in weight. For very large draglines, the weight of which may be as high as 1,200 tons, bearing pressures constitute a more difficult problem, from the difficulty and expense of fitting tracks proportionate to the weight of the machine. The bearing-pressure of the largest machines may be as high as 40 lb. to 45 lb. per square inch. This can be more than halved by the use of large timber mats under the tracks, though loss of time and cost of labour in laying them down is entailed.

The problem of weight and bearing pressure on very large draglines has been solved by the use of what is known as the "walking traction" device. Machines fitted with this device were at first used chiefly on the soft ground alongside the Mississippi River for building levees, but they are finding increasing favour for other classes of dragline work, and hundreds are in use in America. Six of them have recently been put to use in the Nigerian tin fields and five in the English ironstone mines.* Two, weighing over 600 tons each, were supplied to steelworks in Germany in 1939.

Draglines are extensively used for digging drainage ditches and irrigation canals, for widening, deepening or cleaning out existing ones, and for building or "throwing up" banks and levees. Many sizes and designs are available for widths of from 2 ft. to 500 ft. or more, an excellent proof of the wide range of sizes obtainable.

The biggest irrigation job ever undertaken was the Sukkur barrage in India, officially known as the Lloyd Barrage and Canals Construction Scheme, which involved the excavation of approximately 210,000,000 cub. yd. of material in digging over 6,000 miles of canals with bed widths ranging from 6 ft. to 350 ft. Forty-six draglines were used, weighing from 20 tons to 300 tons each, and fitted with buckets of capacities ranging from ⅞ cub. yd. to 10 cub. yd. Work was commenced in 1924 and was completed in 1932. The largest machines, nine in number, weighing 300 tons each, were supplied with booms ranging from 100 ft. to 145 ft. in length, with buckets of capacities ranging from 10 cub. yd. to 6 cub. yd. They were all steam machines, but after three or four years' work with them, and because of the difficulties with coal and water supply, two medium-size Diesel-electric draglines were ordered (electrically operated with 180-h.p. Diesel engines driving 120-kW generators, mounted upon the machine). The boom lengths were: 85 ft. with 4½-cub. yd., 100 ft. with 3½ cub. yd., and 115 ft. with 2½-cub. yd. buckets. They were mounted on caterpillar tracks. Five medium-size steam draglines were also employed, two with 80-ft. booms and 4-cub. yd. buckets, and three with 80-ft. booms and 3-cub. yd. buckets. For the smaller canals, 30 "straight-Diesel" draglines were employed with buckets ranging in size from ⅞-cub. yd. to 1½-cub. yd. capacity.

In Table I is a list of approximate working costs of the various machines, taken over periods ranging from 6 months to 12 months. The costs per cubic yard are operating costs, and include labour, fuel, spares, and repairs, but do not include interest and depreciation. Upon another irrigation scheme in India, the Cauvery-Metur Scheme in the Presidency of Madras, Diesel-electric draglines were used, but were mounted on caterpillar tracks; the cost worked out at approximately 1·2*d.* per cub. yd. It should be noted that the costs given are for the unusually difficult conditions encountered in India, and are chiefly of value for comparing the costs of different sizes and types of machines under similar conditions. In continuation of the above comparisons, it is interesting to note the working costs (Table II, opposite) of the draglines used on the Salonika Plain reclamation scheme. Here again the chief value of the figures is the comparison of the different types and sizes of the machines, all draglines, but in both instances the relatively low costs of the Diesel machines are shown.

TABLE I.

—	Fuel.	Cost of Fuel per Cub. Yd.	Cost per Cub. Yd.
		d.	*d.*
Big steam draglines ..	Coal ..	1·2	3·5
Medium size steam draglines	Coal ..	1·0	2·8
Diesel-electric draglines ..	Diesel oil	0·3	1·9
Small Diesel draglines ..	Diesel oil	0·14	1·4

Draglines are widely used in Great Britain for the cutting of new fen and other drains, the cleaning out of existing channels and rivers from a few feet wide up to 100 ft. or more wide, and the construction and strengthening of embankments. Fig. 2, Plate XXXI, shows a ½-cub. yd. dragline widening a small fen drain with a bottom width of 30 ft. The "throw" of the bucket is clearly shown. Though it is better to employ a machine with a longer boom, to avoid loss of time in throwing the bucket, on many drainage schemes a machine of average size has to be used to suit the different jobs which have to be dealt with. The cost of the job illustrated was about 9*d.* per cubic

* See page 513, *ante*.

THE DRAGLINE EXCAVATOR.

(*For Description, see Page* 571).

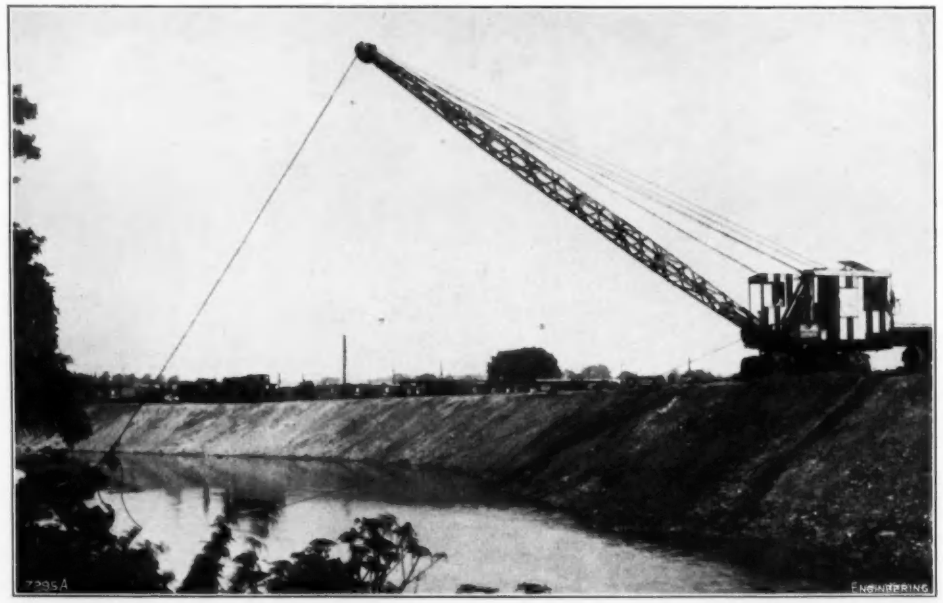


FIG. 1. "THROWING" THE BUCKET FOR DIGGING.

FIG. 2. WIDENING A FEN DRAIN.

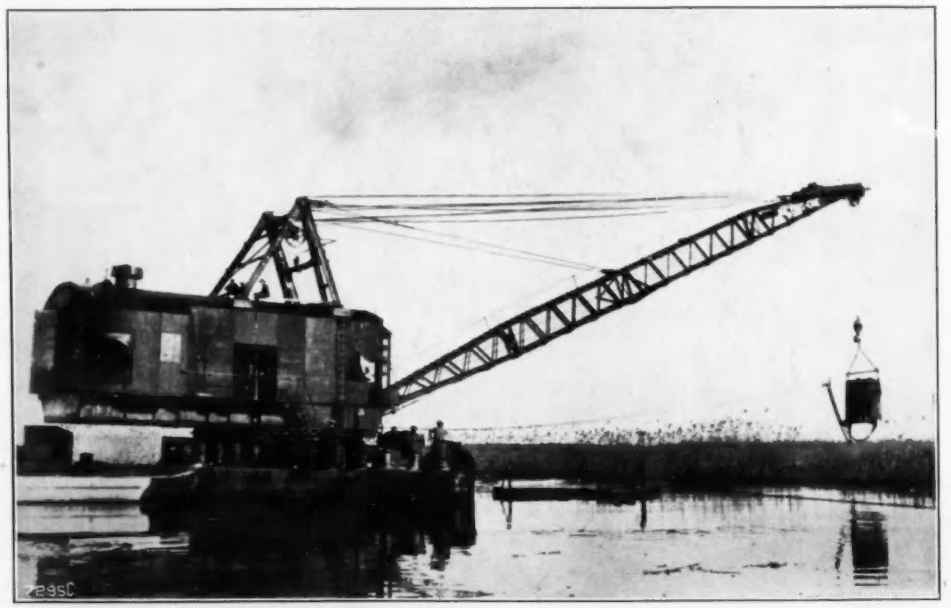


FIG. 3. DRAGLINE EXCAVATOR MOUNTED ON A PONTOON.

FIG. 4. "WALKING" DRAGLINE EXCAVATING STRATIFIED MATERIAL.

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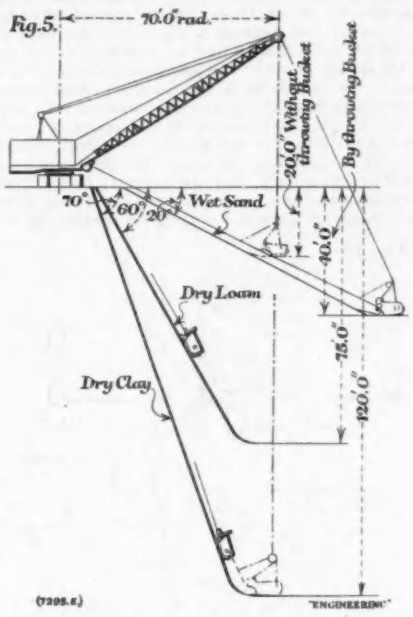
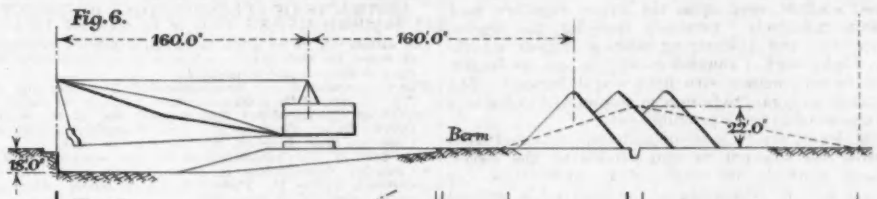
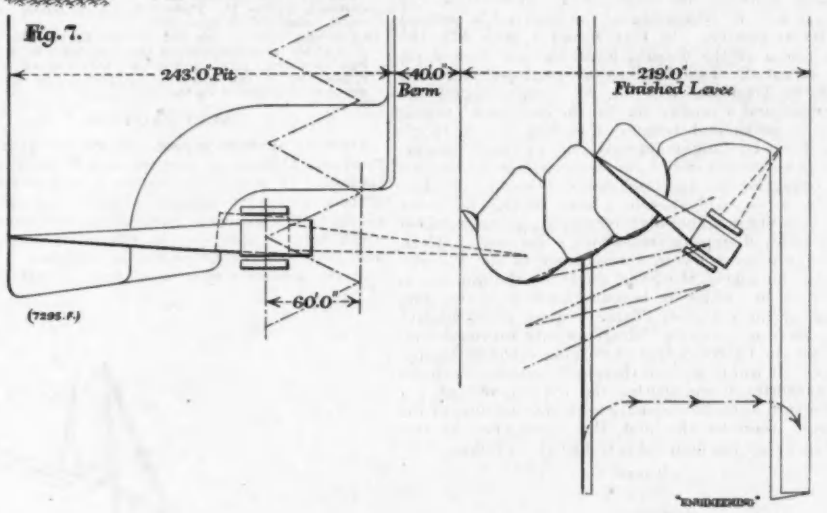
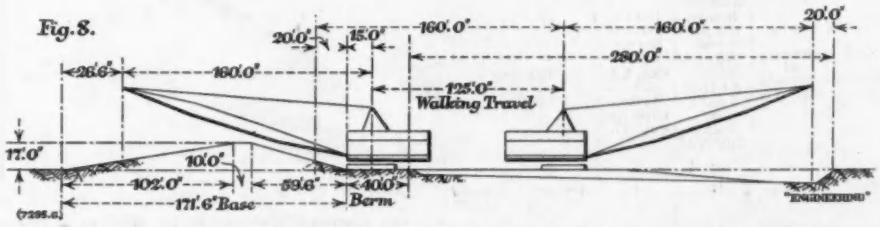
THE DRAGLINE EXCAVATOR.









yard, including trimming the banks and all capital charges and depreciation. Bad travelling conditions increased the cost unduly. Upon another job where the travelling conditions were better, the cost of the excavation, including depreciation, etc., was approximately 4*d.* per cubic yard plus 2*d.* for trimming and sowing the banks. The costs for cleaning out and trimming the banks of another drain about 12 ft. wide at the bottom and 12 ft. deep was 3·8*d.* per cubic yard. This cost included 20 per cent. interest and depreciation and the wages of three men, an operator and two labourers. The cost depends on the size of the drain and the amount of material to be taken out. A small drain, 2½ ft. to 3 ft. wide at the bottom and 8 ft. to 9 ft. wide at the top, can usually be cleaned out for about 12*s.* 6*d.* to 15*s.* 0*d.* per chain, excluding capital charges, but including two men for trimming the banks. Table III gives detailed working costs, taken over a period of 12 months, for a ¼-cub. yd. dragline, fitted with a petrol-paraffin engine, cleaning out a wide drain.

TABLE II.

—	Cost of Fuel and Lubricants per Cub. Yd.	Cost per Cub. Yd.
	Cents.	Cents.
Steam 1¼-cub. yd. dragline (on pontoon)	2·28	5·00
,, 2½ ,, ,, ,, ..	1·99	4·88
Diesel-electric 6-cub. yd. dragline	0·85	2·97
,, 3½-5 ,, ,, ,, (on pontoon)	0·78	3·25
Diesel 2-cub. yd. dragline	0·45	2·29
,, 1½ ,, ,, ...	0·57	2·94
,, ¾ ,, ,, ...	0·36	1·71
Petrol ¼ ,, ,, ...	1·45	3·15

TABLE III.

Item.	Cost per Cub. Yd.
	d.
Paraffin	0·53
Petrol	0·12
Engine oil	0·14
Machinery oil	0·03
Repairs and maintenance	0·28
Miscellaneous	0·05
Labour on and around the machine	3·80
Total	4·95

A large number of ¼-cub. yd. draglines were employed for cutting drainage ditches, 3 ft. to 4 ft. wide and 4 ft. to 5 ft. deep, upon the Zuyder Zee reclamation scheme in Holland. The material was easily-excavated clay or silt. The location and top-width of the ditches were indicated by two men cutting small trenches about a foot wide and a foot deep with one side made to the correct slope of the finished ditch. The final trimming of the slope was made by two men, one on each bank, who worked close up to the dragline to enable the operator to pick up, with the bucket, the material broken down into the bottom of the ditch. Outputs of 5,000 cub. yd. to 5,500 cub. yd., in a working week of 55 hours, were obtained, with a normal average output over long periods of 60 cub. yd. to 70 cub. yd. per hour, this output taking into account all stoppages.

In Table IV, below, are given details of costs for the excavation of a canal from sandy clay, using a dragline with a 1½-cub. yd. bucket, sidecasting, and working two shifts a day (96 hours per week). The average output was 137 cub. yd. per hour (13,152 cub. yd. per week).

TABLE IV.

Item.	Cost per Week.	Unit Costs.
	£ s. d.	
Labour:		
Two operators, at 2*s.* per hour, each	9 12 0	
Two boys, at 9*d.* per hour, each	3 12 0	
Fuel:		
Diesel oil: 319 gallons at 6*d.* per gallon	7 19 6	0·15*d.* per cub. yd. (41 cub. yd. per gal.)
Lubrication, etc.:		
Engine oil: 16½ gallons at 3*s.* per gallon	2 9 6	0·05*d.* per cub. yd.
Machine oil: 2 gallons at 2*s.* 6*d.* per gallon	0 5 0	
Grease: 33 lb. at 3½*d.* per lb. ..	0 9 0	
Cotton waste	0 0 10	
Repairs and maintenance (excluding ropes)	5 10 0	0·1*d.* per cub. yd.
Ropes: derricking rope every 4 months; hoist rope every 2 months; drag rope every 4 weeks	3 9 0	
Total	33 6 10	

Total cost per cub. yd. (excluding capital charges): 0·61*d.*

Sometimes, when it is required to clean out a water-course, the channel may be too wide for the dragline to reach the material from the bank or banks. The dragline is mounted on a pontoon and discharges the excavated material directly on to the bank or into wagons, or barges. Fig. 3, Plate XXXI, shows a large Diesel-electric dragline working upon the Salonika Plain reclamation scheme, referred to in the working costs in Table II. To counteract the digging reaction and to hold the dragline up to its work the pontoon must be fitted either with shore anchors, operated from warping winches attached to the corners of the pontoon, as shown in Fig. 3, or with hand- or power-operated spuds. With a shallow river it is possible sometimes, if the bed is sufficiently firm, to travel the machine in the water and to dump the excavated material upon the banks or into lorries.

A "walking" dragline is shown at work in Fig. 4, Plate XXXI, on the Briegden-Gellick section of the Albert Canal, which runs from Antwerp to Liége.* The dragline, fitted with a 6-cub. yd. bucket on a boom 135 ft. long, is shown working in a deep wide cutting near Lanaeken. The upper portion of the material in this cutting consisted of clay and the lower portion of gravel, both being excavated separately. The clay was used to construct the banks on the lower levels of the canal and the gravel as an aggregate for approximately 80,000 cub. yd. of concrete necessary for lining the sides of the canal. The machine worked, almost continuously, two or three shifts (18 hours to 24 hours a day), for four to five years and excavated about 5,500,000 cub. yd. at the average rate of approximately 100,000 cub. yd. per month. The machine, powered by a 280-h.p. Diesel engine, weighed about 300 tons. The average output was approximately 240 cub. yd. per hour, and the Diesel-oil consumption was approximately 6·5 gallons per hour (about 37 cub. yd. per gallon).

The biggest dragline excavation jobs in the world are the flood-control schemes in the Mississippi basin. Commenced over 200 years ago, by hand labour, they have developed in recent years to highly mechanised schemes. Floods alongside this famous river were recorded by De Soto, the Spanish explorer, as far back as 1543. In 1927, the greatest flood on record occurred and in 1928, and later, large sums were authorised by Congress for levee construction. Since 1928, about 650,000,000 cub. yd. of material have been placed in the levees over an aggregate length of about 2,000 miles. Commencing about 1912, draglines, mostly of the walking type, have been chiefly used for this work because of their very low bearing-pressure on the ground and their ability to side step and zigzag so as to obtain the necessary digging width and to dump the wide levees which have been, and are still being, constructed. Approximately one

* See ENGINEERING, vol. 148, page 375, *et seq.* (1939).

hundred excavators of this type have been, or are being, used upon the various schemes. Because of the heavy cost of coal, and of feed water difficulties, Diesel engines, even upon the largest size, are used almost exclusively. Generally speaking, the digging is very easy and, as dumping radius is of great importance, light steel or aluminium-alloy booms are largely used in conjunction with light-weight buckets. The contract price ranges from a minimum of 8 cents to a maximum of 24 cents per cubic yard.

The levees are built up of material excavated from borrow pits adjacent to, and parallel to, the levees. Several methods are employed to build these big levees, and the rehandling of the material is reduced as far as possible. In Figs. 6 and 7, page 573, the dimensions of the finished levee and the borrow pit are indicated. Two draglines are employed, one with a 160-ft. boom and a 6-cub. yd. bucket digging the material, and a smaller one, on the dump side, taking off the peaks and roughly spreading the material. The final levelling is carried out by hand labour. The three-peaked section on the levee side is obtained by zigzagging the big machine as shown in the plan. In Fig. 8, page 573, showing a levee 171 ft. 6 in. across the base, one dragline only is employed and it is travelled in a series of steps or stages over a distance of 125 ft. It is only necessary to spread some of the material on the far side of the levee, shown by the dimensions 26 ft. 6 in., which is beyond the normal dumping reach of the machine. Table V gives representative outputs from "walking" draglines with varying boom-lengths and bucket-capacities working on the Mississippi levees. It will be noticed that, in the smaller machines with shorter boom-lengths, the average output per cubic yard of bucket capacity is greater, because of the shorter boom-lengths and the consequent shorter distance that the material is transported or dumped.

TABLE V.

Length of Boom. Ft.	Capacity of Bucket. Cub. Yd.	Average Hourly Output (three 8-hour Shifts per Day, 7 days per week). Cub. Yd.	Hourly Average Output per Cub. Yd. of Bucket-Capacity. Cub. Yd.	Remarks.
150	8	350	43	Average monthly output: 245,000 cub. yd.
150	7	280	40	Average monthly output: 195,000 cub. yd.
150	5½	240	43	Maximum output in a month: 285,000 cub. yards (an average of 400 cub. yd. per hour).
120	6	390	65	—
120	6	450	75	—

(To be continued.)

ALSTON MEMORIAL PRIZE.—The Council of the Royal Aeronautical Society has accepted an offer made by Mrs. G. Alston to found a prize in memory of her husband, Mr. Peter Alston, who was killed in a flying accident on February 16, 1939. The prize, an annual one, of approximately 5*l.* in value, will be known as the Alston Memorial Prize. It will be awarded to a student or graduate of the Society in connection with work aiming at the improvement of the safety, and particularly the stability and control, of aircraft.

"THE ENGINEERS' DIGEST."—We have received from The Engineers' Digest, Limited, 59, Weymouth-street, London, W.1, a copy of the first issue of a monthly publication bearing that title, the purpose of which is to present a review of engineering progress abroad as reflected in the foreign technical Press. The *Digest* is edited by Mr. J. Emerich Pajzs, who was formerly secretary of the Czechoslovakian Association of Engineers, and who is assisted by a strong advisory committee of British engineers. The contents of the first issue consist of 34 abstracts, most of which are illustrated, and include a number taken from periodicals published in enemy and enemy-occupied countries, reference to which has been made possible by the assistance of the Board of Trade. Mr. Pajzs, in his foreword, invites criticism by readers, with a view to rendering the *Digest* the more serviceable to British engineers, and we would suggest, as a first and very important step, that references should be given to the volumes and pages of the foreign papers whence the abstracts have been made. The title alone of a publication is hardly a sufficient guide to anyone who might wish to consult the original article. The price of a single issue of the *Digest* is 4*s.* 6*d.*, and the annual subscription, 2*l.* 2*s.* 0*d.*

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

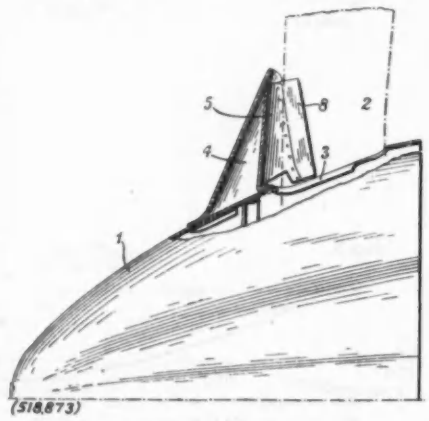
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

518,873. Airscrew Spinner. The De Havilland Aircraft Company, Limited, of Hatfield, and F. M. Thomas, of Hatfield. (7 *Figs.*) September 1, 1938.—The object of the invention is to minimise airscrew drag and improve engine cooling by partly streamlining the blade shanks which are not always of an efficient streamline form, and have little or no propulsive efficiency. In order that the spinner 1 may be mounted on the air-screw,



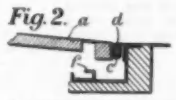
it has rearward openings in its shell at 3 towards, and extending to, the skirt of the shell. Forward of each of these openings a fairing element is built on to the spinner, consisting of a rigid pressing 4 of streamline form. The pressing is flanged and reinforced by an internal part 5, and has attached to it rubber margin elements 8 which bear lightly against the shank 2 of the airscrew blade. The shape of the pressings 4 reduces the deceleration of the air flow in the vicinity of the spinner by reducing the drag which would otherwise be associated with the shanks of the blades. (*Accepted March* 11, 1940.)

MOTOR ROAD VEHICLES.

518,741. Sunshine Roof. Vanden Plas (England), 1923, Limited, of Hendon, and J. Bradley, of Hendon. (3 *Figs.*) August 31, 1938.—The invention is a sunshine roof for saloon cars which is draught-proof. The sliding panel *a* has channel-section carriers *e* along its sides for mounting strips *d* of rubber. Rubber strips d^1, d^2 are secured to the front edge and above the rear edge of the panel, respectively, the strips *d* and d^1 fitting under flanges round the roof opening. The forward end of the panel is supported on guide rails *f* running the full length of the opening and inclined so that, as the panel is slid

Fig. 1.

Fig. 2.



back, its forward end is lowered. The rear end of the panel carries a pair of guides which each engage a rear guide rail *g*. Each rail has a ramp immediately below the rear edge of the opening, so that when the panel is closed the rubber strip d^2 is pressed tightly against the rear flange on the roof. (*Accepted March* 6, 1940.)

STEAM ENGINES, BOILERS, ETC.

519,012. Soot-Blower Drive. Babcock and Wilcox, Limited, of London, and P. G. Handell, of London. (3 *Figs.*) June 9, 1938.—The invention is an automatic reversing gear for operating a soot blower of the type which is projected from a retracted position to the blowing position and then withdrawn. Pawls 1 and 2 are connected together on a common spindle and alternately spring-loaded into engagement with a ratchet wheel 3 which operates the blower tube. The ratchet wheel is keyed to a spindle, one bearing of which is bushed to form a pivot for an oscillating arm 4. Screwed into this arm is the spindle on which the pawls are pivoted. The rear end of the spindle has a vertical slot in which slides a roller on an operating arm which is swung from side to side. At the end of the oscillating arm 4 is a wedge-shaped projection 11 (see Fig. 2), the ridge of which is parallel to the axis of the arm. The pawls are integral with an extension 12 carrying a cup 13 in which slides a plunger having a wedge-shaped head 15 upon which bears a spring. The end of the head engages the wedge

Fig. 1

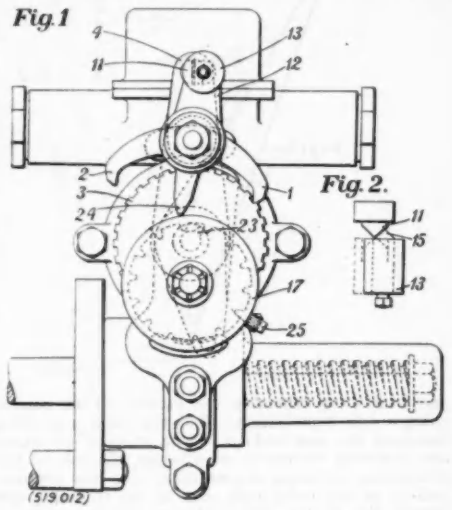
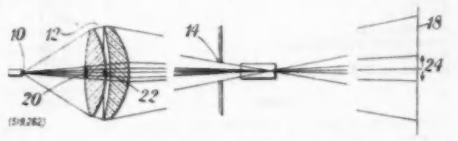


Fig. 2.

11. When the pawl which is actually driving the ratchet wheel rides over the teeth, sliding occurs at the faces of the wedges and the spring biasses the pawl into contact with the ratchet wheel. The sliding is insufficient to carry the ridge 15 on the pawls past the ridge 11, but if the pawls are rotated sufficiently about their pivot, the ridge 15 is carried over the ridge 11 and the spring now biasses the other pawl into engagement with the ratchet wheel. This reverses the drive. The selector consists of an internally-toothed wheel 17 driven from the ratchet-wheel spindle by a single tooth 23 on the end of the spindle. The combined pawls carry a tail 24, and a radial projection 25 on the toothed wheel 17 makes contact with the tail 24 and forces the wedge 15 over the ridge 11 so that the other pawl is engaged to reverse the drive. The internally-toothed wheel 17 also forms part of a mechanism for reducing the speed at which the ratchet wheel 3 rotates while the blower tube is in the blowing position. Engagement between the pawl by which the blower is projected and some of the ratchet-wheel teeth is prevented by a shroud carried by an arm pivoted on the same spindle as the ratchet wheel. The arm is held in position by friction, but can be moved by a projection, extending 60 deg. round the circumference of the wheel 17, when the pawl with which the shroud is associated has completed the greater part of its intended period of operation to move the shroud into its operative position. (*Accepted March* 14, 1940.)

MISCELLANEOUS.

519,262. Background Projector. Gainsborough Pictures (1928), Limited, of London, and A. Davis, of London. (1 *Fig.*) October 10, 1938.—The invention is a projector, for use in "back projection" upon a screen, of a background in front of which the action is performed and photographed, which does not produce a bright spot in the middle of the picture area due to the unequal diffusion of the screen. The projector consists of a light source 10 and a compound condenser 12. The trans-



parency is placed in the aperture 14 and an image of it is thrown on to a screen 18. One of the lenses of the condenser is sand-blasted over the areas 20, 22 on its opposite surfaces. The area 20 on the surface next to the source of light is larger than the area 22, so that a graduated effect is produced on the screen 18 over the area 24, the sand-blasting being carried out in such a way that the diffusive effect is a maximum at the centre and diminishes radially outwards. (*Accepted March* 20, 1940.)